WATREP I–AN INTERACTIVE PACKAGE FOR DESIGN OF WATER TREATMENT PLANT

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By

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CERTIFICATE

It is certified that the work contained in the thesis entitled "*WATREP I - An Interactive Package for Design of Water Treatment Plant*" by *Mr Prashast Kumar Dixit*, has been carried out under my supervision.

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ABSTRACT

WATREP I is a **PC** based interactive package for design of water treatment plants. This package is aimed at providing flexibility in sequential selection of options at various levels during package execution. The package is written in **PASCAL** and uses the **TURBO PASCAL Version 4.0** to provide graphic visuals and to achieve user machine interaction. The menus are divided into four levels and only the menu applicable at a particular stage of operation is displayed. The selections made are displayed simultaneously indicating the path through which an individual final selection is identified.

The unit operations implemented in the current version of the package include aeration, settling, rapid mixing, flocculation, softening, filtration and disinfection. Incorporation of GUIDE option is an attempt to make the selection of a unit from any level more user friendly. This option, whenever summoned at any stage of unit selection assists in identifying the most appropriate unit at that level. On invoking, it displays either of its three levels - **DESCRIBE:** a brief description of (un)favourable conditions for operation, **PERFORM:** performance from the point of view of important and pertinent design parameters and **COMPARE:** a critical comparison of units from the point of view of operating features, cost, problems associated, etc. depending upon user's desire. These three levels of guidelines provide user with an on-line instrument to glance at information relating to various options of a particular level. A post design block is developed which includes plant features like **FLOWSHEET** and **HYDRAULICS**. **FLOWSHEET** generates a graphical interface by queuing the units designed in their sequence of design. **HYDRAULICS** on the other hand calculates the hydraulic parameters and produces an output showing head loss and water surface elevation at key points of the unit. Thus the current package is capable of providing on-line help and guidance for operation and selection respectively, design of a unit, and generating treatment chain and hydraulic gradient line through the plant.

KEY WORDS

Software, Interactive Packages, Computer Graphics, Knowledge Base, Water Treatment Plants, Flow Sheet, Hydraulic Design, Aeration, Settling, Rapid Mixing, Flocculation, Softening, Filtration, Disinfection.

PROLOGUE

The ever expanding frontiers of research in environmental engineering and other sister disciplines have brought about what is called an information revolution in this field. With deepening of knowledge in the field more and more complexities and their consequences are cropping up. Concern to environmental problems is making itself felt worldwide. This is enthrusting additional liabilities and pressure not only to researchers but also to policy architects. This obviously forces the professionals in the environmental world to discover, modify and implement newer, faster and more sophisticated methods of research as well as data collection, acquisition, storage and processing so as to identify, anticipate, control and regulate the causes of environmental insults. Environmental regulation books are more heavier today to accommodate important segments of the knowledge base. As governmental agencies require a feasible correlation of data, the attention of engineers and managers is brought to find out more effective and efficient means to handle the voluminous data bank.

On the other hand the expansion of software and hardware capabilities is presenting environmental management field an increasingly sophisticated tool to carve best results out of a bulky database. Computers are therefore, supplementing the decision making process to a great extent. The present thrust is, therefore, towards developing and using environmental software for the cause of environmental management. In other words, environmental software is an affordable outside source that both large and small entities find helpful for environmental management.

The constraints on the designers/engineers and rapid expansion of treatment technology to cover diversified applications have led to development of interactive packages. It

is, however, surprising to note that interactive packages to serve the purpose of preliminary design of water treatment plant are almost nonexistent. The present work, therefore, is an attempt to dovelope an interactive software for the preliminary design of water treatment plants.

STATE - OF - THE - ART

The history of environmental software presents an interesting outlook. Compared to the developed world wherein number of software for environmental application is doubling each year, we are still in infancy. The trend is very encouraging with the number of software becoming about 16 folds in just a five year span. However, such a steep rise is difficult to expect in India, specially in the present framework.

Compared to USA (a typical of developed countries), Indian scenario (typical of developing countries) is rather dull. There is hardly any software available commercially for ready use. Most government agencies have either not introduced computers for technical application or they use software provided by the world agencies like UNDP, UNEP, etc. However, this does not mean that environmental software development is not attempted so far. In fact, at least 10 good software packages are available for use. A few are already in use by the pollution control agencies. The available software cover various fields of application such as air pollutant dispersion, water quality modelling, water treatment plant design, data base management for water/air, wastewater treatment plant design, ocean outfall design, risk assessment and environmental impact of industries, optimized phased development of treatment plants, etc.

Compared to the software development abroad under tough commercial environment, the Indian development can be termed as in-house as most of the developments are institutional (Funkwal and Tare, 1989). The most important aspect of such software is that they are readily accessible to put them as training and educational tools. For example, programs like INDETREP, INDISPOL,

STREAM-1, STREAM-2, (Funkwal, 1989; Ummat, 1988; Prasad, 1989; Modak *et al.*, 1989) etc. with their interaction with user give a deep insight to the user in their respective fields. While executing INDETREP the user not only gets a good idea regarding the various options available in wastewater treatment plants but also a knowledge bank at his fingertips to select any of the units. Screening of various alternatives with different sets of parameters clearly indicates variation in design with change in design values. Various treatment trains can be examined based on their performance as well as energy cost using performance and hydraulics routines. Similarly STREAM-1/STREAM-2 give a fair account of the stream water quality when a pollutant source meets a stream. In the packages discussed above graphic output plays a very vital role as it tremendously simplifies the visualization of the basic concept of the problem. In fact, these software are not only used as educational tools for students but also as training tools for persons in the field such as environmental managers, Pollution Control Board officers, etc.

Watbase, Airbase and Basin present a classic example of how educational institutes can hook up with environmental agencies to aid data management and decision making. This demonstrates how a simple program can be put to real use in the field. At least four such programs are now used by the Central Pollution Control Board, New Delhi for applications ranging from data management to cess computation and report preparation (User's Manual, 1989). There are various programs like WASP/INDETREP which will face shyness in becoming popular because of their system compatibility. Since INDETREP is supported on ND-500 supermini computer and uses tektroniks interface to produce graphical output, it can be demonstrated and put to work at limited places only. Realizing this problem the developers have now made it PC-compatible with some limitations so as to promote its extensive use (Prakash *et al.*, 1989; Apurb Anand and Dixit, 1990). Similarly, programs implemented on main frame computers also tend to get isolated. Table 1 lists the available Indian environmental software along with their brief description, system compatibilities and possible usage.

Table 1. A Broad Overview of Indian Software for Environmental Applications

Program Type	Program Name	Developers	Capabilities	Required	Usage
Database Management[1]	Airbase/ Watbase/ Industry Basin	IIT,B	Review,Sort,Modify, Retrieve & Storage of Air, Water & River Basin Data	IBM PC/AT EGA Drive	Pollution Control Boards, Industry
Atmospheric Dispersion of Pollutants[2]	INDISPOL	IIT,K	Pollutant Dispersion Under Steady/ Unsteady/Homogenous/Non Homogenous Atmospheric Conditions	IBM PC/AT IBM PC/XT EGA Drive	Pollution Control Boards,Central Monitoring Agency, Ed./Tr.
Computer Mapping [3]	-------	IIT,B	Mapping of Air Quality in Urban Area	IBM PC/XT	Pollution Control Boards
Wastewater Treatment System Synthesis[4]	INDETREP	IIT,K	Unit Selection Support, Design, Performance,Drawing Flowsheet & Hydraulics. Interactive Design Aid	ND 500 Supermini Computer Tektronik Interface	Design Agencies, Industry, Ed./Tr.
Wastewater Treatment System Synthesis[5]	PCINDETREP	IIT,K	Unit Selection Support, Design, Performance,Drawing Flowsheet & Hydraulics Interactive Design Aid	IBM PC/XT EGA Drive	Design Agencies, Industry, Ed./Training
Optimization Wastewater Treatment System[6]	WASP	IIT,B	Phased Synthesis of Waste Water Treatment System	Mainframe Computer	Design & Planning Agencies
Water Quality Modelling[7]	Stream I 'Stream II	IIT,B	Simulate Impact of Shore Discharge of Pollutants in River	IBM PC/AT	Pollution Control Boards,Industry,Ed./Tr.
Water Treatment System Synthesis[8]	WTRP	IIT,K	Unit Selection Support, Selected Unit Design.	ND 500 Supermini Computer Tektronik Interface	Design Agencies Ed./Tr.
Water Treatment System Synthesis[9]	-----	IIT,B	Design Aid and Information System of Water Treatment Plants	IBM PC/AT	Design Agencies Ed./Tr.
Outfall Design[10]	PREDOCOT	IIT,K	Design	Minicomputor	--do--
Risk Assessment [11]		IIT,B	Decision Support System for Industrial EIA	IBM PC/AT	Pollution Control Boards,Ed./Tr.

Ed. → Education; Tr → Training.

Superscript Defination

1- Users's Manual, 1989; 2- Prasad, 1989; 3- Prabhakar, 1986; 4- Funkwal, 1989; Ummat, 1988; 5-Apurb Anand and Dixit, 1990; 6- Naik, 1988; 7- Gelda, 1989; Modak *et al.*, 1988; 8- Sharma *et al.*, 1989; 9- Islam, 1987; 10- Matu *et al.*, 1988; 11- Dhoondia, 1987

OBJECTIVES

The water treatment problem is becoming more and more complex with the introduction of sophisticated treatment units for improving levels of treatment. Moreover, as we are progressing, tremendous information related to the water treatment plant design is pouring in from the laboratory, pilot and field studies. The increasingly complex problems, their solutions and predictability are more difficult than ever. Obviously this demands the environmental world to adopt newer faster and more advanced methods of data acquisition, storage, processing and analysis. Computers are therefore playing useful role in finding solutions to these problems. Computers not only supplemented considerably the analytic capability of the designer but also made it possible for him to quickly scan through various treatment options and their possible outcome. The application of user oriented programs known as interactive programs or interactive packages in the field of water treatment works are becoming very popular these days for obvious reasons.

The present work, therefore, is an effort to produce an integrated environment for - first knowledge base aided - user controlled unit selection to provide information on units to ease process of decision making, quick design and rapid evaluation of alternative treatment schemes; second, conceptual drawings preparation for tender documents; and third providing a post design block to draw flow sheet and compute hydraulic grade line through the plant to assist in preparing preliminary layout and arriving at approximate energy costs associated with the scheme of units adopted. The overall objectives can be briefed as follows.

* Development of a knowledge base to assist user in unit selection process.
* Providing a flexible unit selection system through which user can navigate with ease.
* Costing of units based on cost functions.
* Development of a post design block of flow sheet, hydraulic profile and conceptual drawings for tender preparation.

It is pertinent to point out here that the particular package is not an attempt to get the optimal design of a unit nor to take up optimization as an extension of the work. The package is developed as an aid to speedy design, decision making and implementation of the units selected. The suitability and economy of a particular unit under a specific situation is subjective and its decision is left to the user of the package.

SCOPE

The present study is limited to the development of the following aspects of the package.

* Development of an overall master menu selection system for the selection of units.
* Design of treatment units to include aeration, settling, rapid mixing, coagulation-flocculation, softening, filtration and disinfection processes.
* Preparation of conceptual diagrams for the units implemented in the current package.
* Preparation of flow sheets.
* Preparation of hydraulic profiles.
* Development of a guidance system in the package to guide the user on unit selection at various levels.

OVERALL STRUCTURE OF WATREP I

The overall structure of the package is schematically represented in Figure 1. Guidelines are available at all levels wherever selection of an option from a set of options is required. Unit identification causes the design of Unit,generation of graphical and digital output and formation of the process chain by enqueing the designed units. The post design features are available at the end of design of each unit, which when invoked shall display all the units selected in the form of a flow sheet and hydraulic profile. The package program is written in PASCAL, a computer programming language.

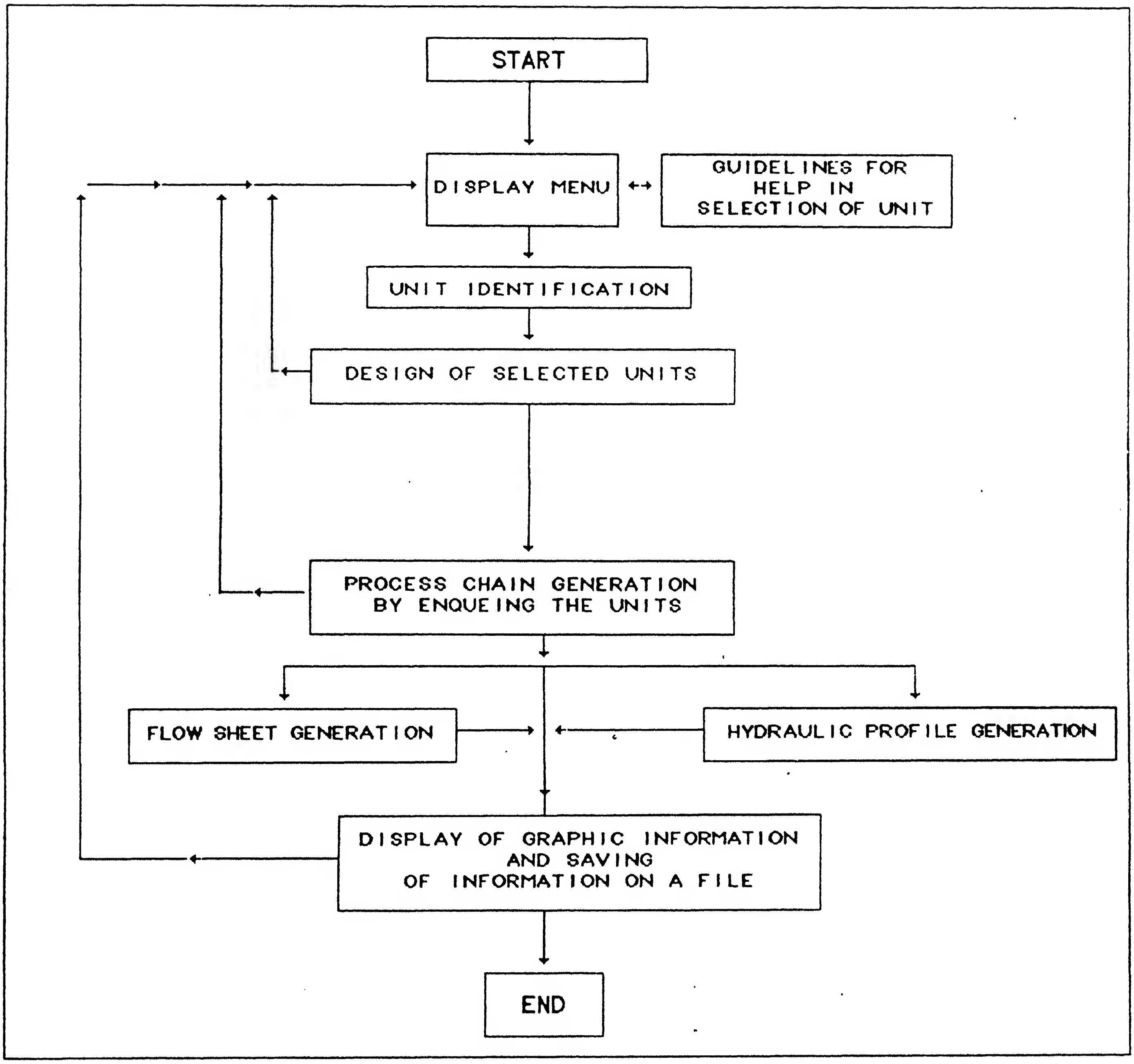


Figure 1. Overall Structure of WATREP I

General Program Logic: The present package has been developed keeping in view the general nature of the package and expected usage by the end user. Since the ultimate objective of the package is to provide the user a workable design of Water Treatment Plant and also give sufficient flexibility to select a unit depending upon one's judgment, the algorithm has been developed as a multi branched selection process which logically ends into the design of the selected unit and its placement in the queue to develop a chain of process for water treatment.

The graphic visuals and interaction are accomplished by TURBO PASCAL- VER 4.0. The current version of the package and its subsequent modifications can run on IBM PC XT/AT or compatible with or without color monitor. The package itself is protected from unauthorized use by a password code without which it cannot be opened by the user.

The algorithm of the package can be represented by a macro flow chart given in Figure 2. The logic can be broadly divided into following main heads.

* Package access code, cover page and general utilities.
* Menu generation and selection of the process unit.
* Design of selected unit.
* Generation of digital and graphical output and enqueing the unit in its proper place in the treatment chain.
* Generation of flow sheet.
* Computation of hydraulic profile.
* Display of graphic information.
* Saving of graphic information on a file in the user area for future reference and retrieval.

For speedy processing and to avoid any memory problems, the entire package is made up of different programs which are executed with proper controls through a batch file in MS-DOS environment (ver 3.3 or later).

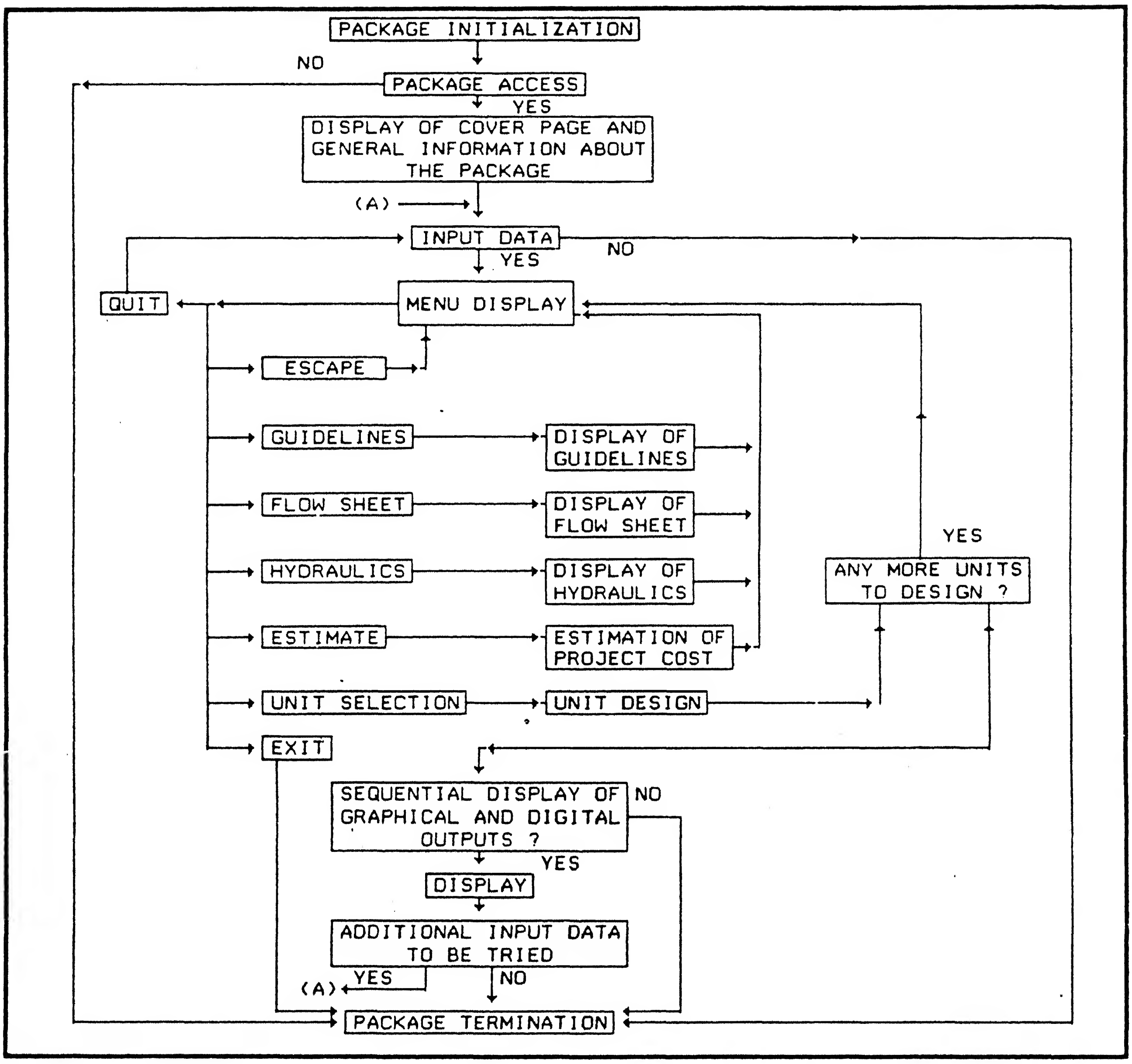


Figure 2. Macro Flow Chart of the Package WATREP I

Menus and Unit Selection: All selectable items of a menu are written in individual boxes. The selection of a menu item is affected through cursor keys on the keyboard. The forward movement of the user through the list of menus is caused by pressing space bar and in main menu through selection of STAY/NEXT option. The package is designed to provide the user "on line help" to guide him through the package. The movement of the user through the package is controlled by menus and prompt messages. The selection of units is done through menus and the design of unit proceeds through prompt messages. The details of the menus and their levels are shown in Figure 3.

Other Options: The help is obtained by selecting HELP or pressing F1. The other options provided for easy movement in the current package include NEXT (F3) option to start design of units, QUIT (F4) option to exit from the package while deleting all the digital and graphic files which occupy storage on the Hard Disk. PRINT (F5) option to print the digital and graphical output or screen display and EXIT (F6) to restart the selection and design with new set of influent Parameters.

Process Units and their Design: Each unit to be designed is identified by a unique unit number and is referred to by that number throughout the program execution. The units which have been incorporated in this package and their identification numbers are given in Table 2. The methodology adopted for the design of various units is presented in the section on "Unit Design Methodology".

For the purpose of design, some design parameters, depending upon the unit to be designed, are to be supplied by the user. All such user defined parameters are backed up by the default values which are assigned to respective parameters and provided with an user option to retain or alter that value. The final design itself is subject to approval by the user and package proceeds only if the design is accepted.

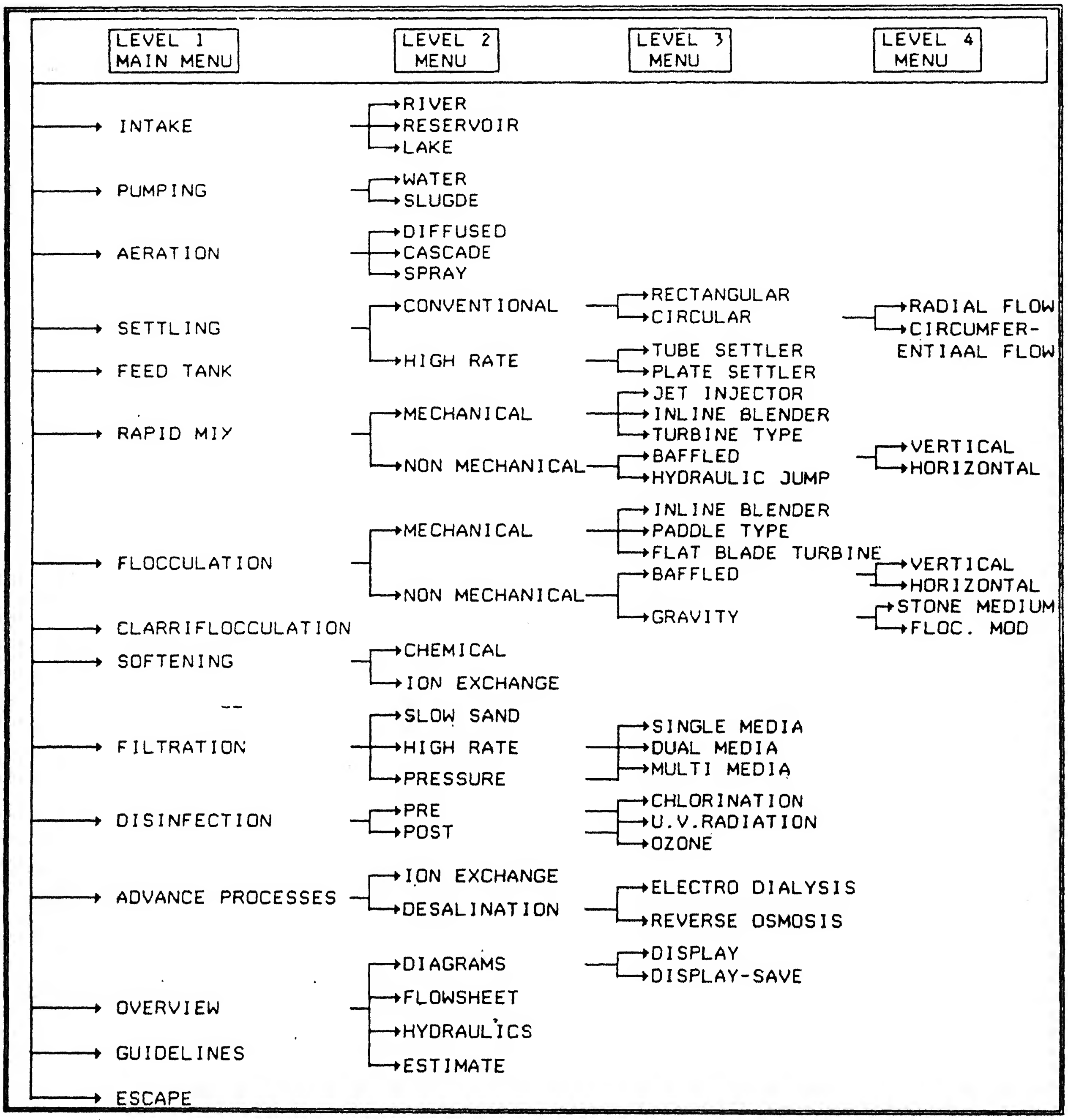


Figure 3. Menu Structure of WATREP I

Table 2. Identification Number Associated with Different Units

UNIT	TYPE	IDENTIFICATION NUMBER
AERATION	DIFFUSED	1100
	CASCADE	1200
	SPRAY	1300
SETTLING	HIGHRATE TUBESETTLER	2110
	HIGHRATE PLATESETTLER	2120
	RECTANGULAR	2210
	RADIALFLOW CIRCULAR	2221
	CIRCUM.FLOW CIRCULAR	2222
RAPIDMIX	JETINJECTOR	3110
	INLINE BLENDER	3120
	TURBINE TYPE	3130
	VERTICAL BAFFLED	3211
	HORIZONTAL BAFFLED	3212
	HYDRAULIC JUMP	3220
FLOCCULATION	INLINE BLENDER	4110
	PADDLE TYPE	4120
	FLATBLADE TURBINE	4130
	VERTICAL BAFFLED	4211
	HORIZONTAL BAFFLED	4212
	STONE MEDIUM	4221
	FLOC MOD	4222
CLARRIFLOCCULATION		5000
FEED TANK		5100
SOFTENING	CHEMICAL SOFTENING	6100
	ION EXCHANGE SOFTENING	6200
FILTERATION	SLOW SAND FILTERATION	7100
	SINGLE MEDIA HIGH RATE FILTERATION	7210
	DUAL MEDIA HIGH RATE FILTERATION	7220
	MULTI MEDIA HIGH RATE FILTERATION	7230
	SINGLE MEDIA PRESSURE FILTERATION	7310
	DUAL MEDIA PRESSURE FILTERATION	7320
	MULTI MEDIA PRESSURE FILTERATION	7330
DISINFECTION		
1. PRE	CHLORINATION	8110
	U.V. RADIATION	8120
	OZONE DISINFECTION	8130
2. POST	CHLORINATION	8210
	U.V. RADIATION	8220
	OZONE DISINFECTION	8230
ADVANCE PROCESSES	IONEXCHANGE	9100
	ELECTRODIALYSIS	9210
	REVERSE OSMOSIS	9220

Output Generation and Chain Development: The output of the results is achieved in two modes, i.e. digital and graphic. In the digital mode, the design of the units, its parameters and dimensions are written in a output file created by the package. The graphical output consists of the conceptual orthographic projections which show the schematic plan, elevation/side view and also graphically writes the design results on the screen. Each drawing is stored in an individual file associated with the proper unit.

A record is kept of the sequence in which the individual units are selected and designed by writing unit identification numbers in sequence in a system file MENU.OUT. This file is used for queuing whenever any operation is carried out.

Display and Saving of Graphic Information: Once a chain of treatment units is selected to achieve desired water treatment goal to the satisfaction of the user, all diagrams can finally be redisplayed in the sequence in which they were generated. The selection of display-save option uses the graphic information generated to be saved into a retrievable file. Once saved, the graphic information can be retained and retrieved even after the termination of the package. Saving of graphic information also enables it to be transmitted to a printer for a hard copy output after termination of the package.

Utility of the Package : The software provides the user with a powerful tool to quickly design a treatment process chain, evaluate it and rapidly scan through it's various alternative schemes to arrive at the best one, suited to a particular situation. The package also provides conceptual drawings for the preparation of tender documents rapidly for each units and the plant as a whole.

The Package Programs: The package consists of several programs which in turn consists of several procedures and functions. Following is a list of programs and their functions in brief.

1. ACCESS.PAS: Initializes package and allows execution of package only if correct passcode is given.

2. COVER.PAS: Displays cover page and gives general utilities and information about the package.

3. MAKEDATA.PAS: Asks for influent water parameters from the user and records them in a pascal file COMPARA.DAT to be used in design of the units.

4. MENU.PAS: Displays menu of various levels, allows selection of an individual unit through forward or backward movement, gives help messages to have desired movement in the package and guides in making appropriate selections. Displays conceptual diagrams, flow sheet and hydraulic grade line while executing the package.

5. DISPLAY.PAS: It displays and makes hard copy outputs of the graphical outputs produced during design and hydraulic analysis.

6. ASK.PAS: It is a program for asking from the user whether he wants to see the flow sheet and hydraulic gradient lines.

7. SPEED1.PAS: Program to design aeration units.

8. SPEED2.PAS: Program to design settling units.

9. SPEED3.PAS: Program to design rapid mix units.

10. SPEED4.PAS: Program to design flocculation units.

11. SPEED5.PAS: Program to design softening units.

12. SPEED6.PAS: Program to design filtration units.

13. SPEED7.PAS: Program to design disinfection units.

14. TERMINAT.PAS: It gives information to the user about files where the digital, graphical outputs are stored. It also deletes the dummy files which are not needed after exiting from the package. It also terminates the package execution after displaying the end cover page and returns to the operating system DOS.

Auxiliary and Other Files: The execution of the package involves the use of several auxiliary files which include DOS commands, TURBO PASCAL files, unit UNITSONE, unit DEFVALUE and unit MENUPROC files created to achieve desired functions. The auxiliary files UNITSONE, MENUPROC and DEFVALUE contain a number of procedures and functions to (1) compute mathematical

functions, (2) check wrong entries of real and integer variables and ask for proper response, (3) check whether response given by user is correct, (7) display default data, (8) allow change in default data with user supplied information, (9) display messages etc., (10) draw flow sheet, and (11) display guidelines. Other units used by the package programs are listed as follows.

1. AERATION.PAS: Contains procedures and functions for unit design and generating orthographic projections. It also writes design data in digital as well as graphical form for aeration unit on console as well as hard disk to facilitate the accessing of outputs. It is used by program SPEED1.PAS.

2. SETTLING.PAS: Serves same purpose as AERATION.PAS for settling units. It is used by program SPEED2.PAS.

3. RAPIDMIX.PAS: Serves same purpose as AERATION.PAS for rapid mix units. It is used by program SPEED3.PAS.

4. FLOCCTON.PAS: Serves same purpose as AERATION.PAS for flocculation units. It is used by program SPEED4.PAS.

5. SOFTNING.PAS: Serves same purpose as AERATION.PAS for softening unit. In addition it contains procedures to select rapid mix, flocculation and settling units while designing chemical softening. It is used by program SPEED5.PAS.

6. FILTER.PAS: Serves same purpose as AERATION.PAS for filtration units. It is used by program SPEED6.PAS.

7. DISINFC.PAS: Serves same purpose as AERATION.PAS for disinfection units. It is used by program SPEED7.PAS.

8. HYDPROF1.PAS: It contains procedures for calculating hydraulic parameters and displaying and saving of digital and graphical output for water storage tank, aeration and settling units.

9. HYDPROF2.PAS: Serves same purpose as HYDPROF1.PAS for rapid mix, flocculation and softening units.

10. HYDPROF3.PAS: Serves same purpose as HYDPROF1.PAS for filtration and disinfection units.

In addition to auxiliary files there are several input and output files which are required/created in the execution of the package. These files can be classified in three categories (i) dummy files (ii) digital output files (iii) graphical output files. Dummy files are created to transfer proper control within

the package between different program executions and are deleted automatically upon the termination of the package or in between execution. Digital files contain digital functional design output and hydraulic design values. These files can be easily displayed and printed on a printer like other DOS text files. Graphical output files can be viewed or printed on printer by executing DISPLAY.EXE. The graphical files are different from text files, hence, cannot be viewed without executing DISPLAY.EXE.

The Graphic Database: In order to draw the orthographic projections of a unit designed by the package and accepted by the user, a mathematical model of each structural unit should be built up as a set of nodal co-ordinates in the cartesian co-ordinate system and a connectivity list of all nodes of the structure. These two informations are to be stored in procedures associated with drawings or orthographic projections of individual units. Since the dimensions of each unit depend upon many variables which may change from time to time depending upon the input data and the selections made by the user, no fixed co-ordinates can be assigned to the identified nodes. The situation is further complicated by the fact that the dimensional ratios such as length to width ratio, width to depth ratio, etc. are user defined and may change the entire geometry of structure from square to rectangular, from shallow and large to deep and small. To achieve this flexibility, actual co-ordinates should be fixed depending upon the limiting maximum dimension (length or width for plan, length or depth for elevation and width or depth for side view) so that the final drawing fills the available space. Currently, only conceptual drawings, irrespective of the actual dimensions, have been adopted. However, this can easily be extended to variable dimensions.

STRUCTURE OF GUIDE OPTION

Option GUIDE is included in the current version of the package to equip the user with an on - line guidance for selection of units. Structurally this option resembles HELP

option of the package. However, they are designed to serve two different purposes. While the HELP gives useful information for package operation and next activity user is supposed to perform, GUIDE option will guide him to pick the most suitable unit processes/operations available at any instant. GUIDE, thus, is designed in such a manner that it enables user to quickly evaluate and rate the unit against his requirements.

On invoking this option the text of guidance is read from the appropriate pascal files with extension GUD and displayed on screen. The guidelines are structured in a format to facilitate on - line comparative study of options available at user's disposal. To further its utility GUIDE is subdivided into three sub options, namely DESCRIBE, PERFORM and COMPARE. DESCRIBE option illustrates in brief the relative merits/demerits, favourable/unfavourable conditions and limitations of unit at the current level. PERFORM option shows a compilation of design parameter data for performance of various units at current level. This helps in rating the unit from performance point of view. COMPARE option shows a critical comparison of units against various significant parameters which help in selecting the unit by comparing the units against these parameters. In COMPARE option the rating is expressed in numbers 0 - 10 or letter grades A to F. The text of these three sub options of GUIDE at various levels of unit selection is presented in Appendix I.

UNIT DESIGN METHODOLOGY

The process of selection through successive menu levels identifies a unit which is uniquely defined by a unit number. Upon correct identification of the unit, the same is designed as per accepted norms of design. The design is initiated by assigning default values to user modifiable design values. These values are then displayed one by one and the user is allowed to either retain the default value or give a new value. The design proceeds with the final values so selected. The design procedure is based on the compilation of the state-of-the-art and is presented giving various steps involved. An overview of the unit

design methodology giving reference to relevant literature is presented in Table 3.

STRUCTURE OF POST DESIGN FEATURES

Post design features include DIAGRAMS, FLOWSHEET, HYDRAULICS and ESTIMATE options. The description of these options is as follows.

FLOWSHEET Option: This option provides user a tool to review the schematic flow sheet of treatment chain generated by selection of designed units. This selection çan be opted after selection or design of a unit. On selection it shows the treatment chain with the schematic flow connections of units selected or designed till that stage in accordance to their selection sequence. As the unit selection process progresses to form a treatment chain, the unit numbers are written in a Pascal file in a sequence and the flow scheme of a unit drawn is queued up with the previous unit appropriately.

While structuring this option more emphasis was laid on flow scheme of various units and their appropriate connections with preceding and following units, than on detailed drawings of the units. Therefore, simplified outlines of units have been incorporated.

HYDRAULICS Option: The design of water treatment plants involves process design as well as hydraulic analysis. Hydraulic analysis is opted after design of all units in treatment chain. This is required to compute the head loss through plant. The head loss computations in turn help in laying out the plant units appropriately and in computing energy cost for pumping involved. Many a times, therefore, hydraulics form a very important factor while considering alternative schemes. It is with these considerations that this option is added to the package. This option can be selected after design of a unit. Each time it is selected, it computes water surface elevations and head loss

Table 3. An Overview of the Unit Design Methodology

UNIT	REFER TO Design Logistics on Page	APPENDIX II Equation Block(s)	Literature
1. Diffused Aeration	80	1, 2, 3	Manual on Water Supply and Treatment (1984)
2. Cascade Aeration	81	4, 5, 6	Nakasone (1987)
3. Spray Aeration	82	7, 8	Manual on Water Supply and Treatment (1984)
4. Tube Settler	83	9	Yao (1973); Eshwar and Tare (1981); Fadel and Baumann (1990);
5. Plate Settler	84	10	Yao (1973); Eshwar and Tare (1981); Fadel and Baumann (1990); Smethurst (1987);
6. Rectangular Settling Tank	85	11, 12 13, 14	Hudson (1981); Culp *et al.* (1986); Manual on Water Supply and Treatment (1984)
7. Radial Flow Circular Settling Tank	87	15	Hudson (1981); Culp *et al.* (1986); Manual on Water Supply and Treatment (1984)
8. Circumferential Flow Circular Settling Tank	88	16	Hudson (1981); Culp *et al.* (1986); Manual on Water Supply and Treatment (1984)
9. Inline Blender Rapid Mix	89	17	Culp *et al.* (1986); Hudson (1967); Camp and Stein (1943);
10. Turbine Type Rapid Mix	89	18	Culp *et al.* (1986); Hudson (1967); Camp and Stein (1943);
11. Vertical Baffled Rapid Mix	90	19, 20 21	Bhole *et al.* (1987);
12. Horizontal Baffled Rapid Mix	91	22, 23, 24	Bhole *et al.* (1987);
13. Inline Blender Flocculator	92	25	Culp *et al.* (1986);
14. Paddle Flocculator	93	26, 27, 28	Culp *et al.* (1986); Fair *et al.* (1968);
15. Turbine Type Flocculator	94	29, 30	Culp *et al.* (1986);
16. Vertical Baffled Flocculator	95	31, 32 33	Bhole *et al.* (1987); Manual on Water Supply and Treatment (1984)
17. Horizontal Baffled Flocculator	97	34, 35 36	Bhole *et al.* (1987); Fair *et al.* (1968); Manual on Water Supply and Treatment (1984)
18. Chemical Softening	98	37, 38	Manual on Water Supply and Treatment (1984)
19. Ion Exchange Softening	99	39, 40, 41, 42	Manual on Water Supply and Treatment (1984)
20. Slow Sand Filter	102	43, 44	Huisman and Wood (1974); Dhabadgaonkar (1977); Swamy (1975); Dhabadgaonkar and Bhole (1974); Manual on Water Supply and Treatment (1984); Bhole (1975c)
21. High Rate Single Media Filter	103	45, 46, 47, 48, 49, 50, 51, 52	Culp *et al.* (1986); Bhole (1975b); Manual on Water Supply and Treatment (1984)
22. Pre Chlorination	105	53, 54, 56	Manual on Water Supply and Treatment (1984); Patwardhan (1977b); Tikhe (1976)
23. Post Chlorination	106	57, 58, 59	Manual on Water Supply and Treatment (1984); Patwardhan (1977b); Tikhe (1976)

through units designed till that stage after queuing them in appropriate order.

Sub critical flow is controlled by downstream control points and super critical flow is controlled by upstream control points according to the fundamentals of hydraulics. Downstream conditions can not be propagated back against super critical velocities. Water treatment plants normally involve sub critical flow conditions, thus hydraulic profiles are primarily determined by downstream control points.

The starting point for calculation of head loss through various units in the plant and setting elevations of the control points to produce calculated hydraulic profile has been taken as Clear Water Reservoir.

As the design progresses a procedure records all units designed to generate a queue of treatment processes. When HYDRAULIC option is invoked it reads sequence of units from the above said queue and computes the water surface elevations at key points in addition to head loss in the units. Once elevations of various key points are computed it shows these results in graphical form and writes the digital output in a Pascal file. These digital and graphical outputs can be accessed later on. This procedure uses two Pascal files MENU.OUT and CONNECT.HYD. MENU.OUT stores the unit selections in a queue and CONNECT.HYD contains the values of head loss until that unit and Total Head needed.

It should be noted that the hydraulic calculations for exact head loss are possible when all minor details of connections and connection lengths are available. This depends largely on the layout of units at plant site, which usually is not available with user while preparing preliminary designs. Hence, hydraulic option computations are subject to this constraint.

The fundamental mathematical equations used for calculation of head loss, head gain or head over weir are summarized in

Table 4. Each expression is given a Expression Identification Letter (e.g. A, B, C, etc.). Table 5 presents a list of expressions used in computing head loss through a unit operation.

DIAGRAMS Option: Selection of this option permits the user to view the conceptual orthographic drawings on the terminal and save them to disk files on the current drive after the design of units. This option has two sub options DISPLAY and DISPLAY-SAVE. On selection of the option DISPLAY the conceptual orthographic drawings along with hydraulic grade line are displayed sequentially on the terminal. On selection of the option DISPLAY-SAVE the graphic files are retained on disk even after exiting the package. However, the aforesaid diagrams are shown and saved only when either design has been done or/and hydraulic grade line has been computed by hydraulic option.

ESTIMATE Option: This option is provided to give preliminary cost estimate of individual units as well as of the overall plant. After the functional and hydraulic design has been completed selection of this option gives preliminary estimates for budgetary purposes.

The cost of a water treatment system includes costs of rapid mix unit, slow mix unit, settling unit and other units. These costs (civil, mechanical and electrical) depend on the size of the individual treatment units adopted. While civil cost mainly includes cost of construction, the mechanical and electrical costs relate to the equipment and accessories necessary for effective operation of the treatment unit.

There are two approaches of cost estimation. One uses detailed structural design to compute the quantities of materials required. The current rates are then applied to calculate quantities for estimating cost. However, this approach is not advisable in the packages which are prepared to serve as design packages for many treatment units, but are suitable for packages structured to perform detailed design of a particular unit. The second approach uses cost data available for units of various

Table 4. Expressions used for Head Computation and their Identification Class

HEAD LOSS/HEAD GAIN HEAD COMPUTAION FOR	EXPRESSION USED	EXPRESSION IDENTIFICATION
Losses:		
Friction in Pipe	$\Delta H = (f.L.U^2)/(2.g.D)$	A
Bend in Pipe	$\Delta H = (K_{hb}.U^2)/(2.g)$	B
Entrance to Pipe	$\Delta H = (K_{ent}.U^2)/(2.g)$	C
Exit to Pipe	$\Delta H = (K_{ex}.U^2)/(2.g)$	D
Flow in Lateral Channel Spillway	$\Delta H = \left[\frac{2.(m.q_o)^2}{g.W^2.y_L} + y_L^2\right]^{0.5} - y_c$	E
Bend in Channel	$\Delta H = (K_{hb}.U^2)/(2.g)$	F
Expansion in Channel	$\Delta H = K_{exp}(U_1^2 - U_2^2)/(2.g)$	G
Contraction in Channel	$\Delta H = K_c(U_2^2 - U_1^2)/(2.g)$	H
Flow Control Valves	$\Delta H = (K_{gate}.U^2)/(2.g)$	I
Orifice Entry	$\Delta H = \left[\frac{Q}{C_d.A_o.(2.g)^{0.5}}\right]^2$	J
Free Falls	ΔH = Provided Free Fall	L
Gains:		
Pumping	ΔH = Pumping Head Applied	M
Computations:		
Head on Rectangular Weir	$\Delta H = \left[\frac{1.5Q}{C_d.L.(2.g)^{0.5}}\right]^{2/3}$	N
Vertical Baffled Channel	$\Delta H = 0.153(G.t)^{0.47}$ + Number of Channels.Width of Channel. Slope of Channel	P

continued on page 23

continued from page 22

Horizontal Baffled Channel	$\Delta H = 0.153(G.t)^{0.47}$ + Number of Channels.Width of Channel. Slope of Channel	Q
Baffled Channel	ΔH = [{Number of Channels.(Velocity in Channels)^2}+{(Number of Channels - 1).(Velocity in Slots)^2}]/(2.g)	R
Sand Bed	$\Delta H = \dfrac{k.\mu_T.v.(1 - \varepsilon_{sand})^2 L}{g.\rho.\varepsilon^3_{sand}} (\frac{6}{d})$	S

A_o = area of orifice, m^2; C_d = coefficient of discharge; d = diameter of sand grains, m; D = diameter of pipe, m; f = coefficient of friction in pipe; g = acceleration due to gravity, m s^{-2}; G = velocity gradient, s^{-1}; ΔH = head loss or head gain, m; K_{hb} = coefficient of head loss due to bend in pipe; k = constant; K_{ent} = coefficient of head loss due to entrance in pipe; K_{ex} = coefficient of head loss due to exit from pipe; K_{gate} = coefficient of head loss due to flow control valves; L = length of unit, m; m = number of weirs per unit length; t = hydraulic retention time, s; Q = flow rate, $m^3 s^{-1}$; U = longitudinal velocity, m s^{-1}; U_1 = longitudinal velocity in wider section, m s^{-1}; U_2 = longitudinal velocity in contracted section, m s^{-1}; v = vertical velocity, m s^{-1}; q_o = flow rate per weir, $m^3 s^{-1}$; W = width of lateral spillway channel, m; y_c = depth of flow in lateral spillway channel at discharging end, m; y_L = depth of flow in lateral spillway channel at far end, m; μ_T = dynamic viscosity, Kg m s^{-1}; ε_{sand} = porosity of sand grains, %; ρ = mass density of water, Kg m^{-3}.

Table 5. List of Expression used for Head Computation in Various Units

	UNIT NAME	LIST OF EXPRESSIONS USED
1.	Diffused Aeration	D, C
2.	Cascade Aeration	D, N, L, C
3.	Spray Aeration	A, B, I, A, B, A, B, I, A, L, C
4.	Tube Settler	D, A, N, L, C
5.	Plate Settler	D, A, N, L, C
6.	Rectangular Settling Tank	D, E, J, N, L, N, L, J, C
7.	Radial Flow Circular Settling Tank	A, B, A, D, N, L, E, C
8.	Circumferential Flow Circular Settling Tank	D, E, J, N, L, E,C,A,B,A
9.	Inline Blender Rapid Mix	D, C
10.	Turbine Type Rapid Mix	D, C
11.	Vertical Baffled Rapid Mix	D, N, L, P, N, L, C
12.	Horizontal Baffled Rapid Mix	D, Q, N, L, C
13.	Inline Blender Flocculator	D, C
14.	Paddle Flocculator	D, C
15.	Turbine Type Flocculator	D, C
16.	Vertical Baffled Flocculator	D, N, L, R, N, L, C
17.	Horizontal Baffled Flocculator	D, N, L, R, N, L, C
18.	Ion Exchange Softening	D, L, S, C
19.	Slow Sand Filter	D, S, N, L, C
20.	High Rate Single Media Filter	D, N, L, S, C
21.	Pre Chlorination	D, N, L, R, N, L, C
22.	Post Chlorination	D, N, L, R, N, L, C

capacities based on which cost functions can be generated. Cost functions relate cost of a unit with most influential design parameter(s). This approach requires collection of cost data from previously constructed plants. The second approach is considered to be appropriate for this package. Due to time constraints, the option of cost-estimates could not be implemented in the present development of WATREP I.

PACKAGE OPERATION AND USER INTERACTION

Loading and compiling to disks of various program files through TURBO PASCAL VERSION 4.0 on any IBM PC compatible creates files with extension .EXE which can then be executed in MS DOS environment without entering into TURBO. A list of package files, Turbo Pascal and DOS files which should be available to operate the package on the disk is presented in Table 6. The execution of the program requires a batch file which contains a set of commands to execute various programs in a sequence determined by user's response. The package execution starts with the command

C:\>WATREP

The very first input the package requires is the package access code. In the absence of the correct access code, the package cannot be opened/initialized. Once the correct code has been identified, the influent data is asked for which has to be given by the user. If the user does not give the influent data the package comes up with the prompt

>DO YOU WANT TO TEST THE PACKAGE WITH THE DEFAULT INPUT DATA(Y/N):

If the user responds with N, the package execution is terminated. Upon successful reading of user specified input data through the terminal from the user or with user's response Y to the above prompt, cover page of the package followed by general information about the package is displayed on the screen and the user is asked to continue with appropriate prompt. The package

Table 6. List of Files Required For Execution of WATREP I

TURBO PASCAL FILES

GRAFCGA.ASM	GRAFEGA.ASM	GRAFHGC.ASM	TGINST.BAT	CGA.BGI
EGAVGA.BGI	HERC.BGI	GOTH.CHR	LITT.CHR	SANS.CHR
TRIP.CHR	GRAFCGA.DVR	GRAFEGA.DVR	GRAFHGC.DVR	BINOBJ.EXE
14X9.FON	4X6.FON	8X8.FON	FLOAT.INC	GRLINK.MAK
ERROR.MSG	GRAFCGA.OBJ	GRAFEGA.OBJ	GRAFHGC.OBJ	GDRIVER.TPU
GKERNEL.TPU	GRAPH.TPU	GSHELL.TPU	GWINDOW.TPU	

WATREP I FILES

WATREP.BAT	G1.GUD	G10.GUD	G11.GUD	G12.GUD
G13.GUD	G14.GUD	G15.GUD	G16. GUD	G17.GUD
G19.GUD	G2.GUD	G22.GUD	G23.GUD	G24.GUD
G25.GUD	G26.GUD	G28.GUD	G29.GUD	G3.GUD
G30.GUD	G4.GUD	G5.GUD	G6.GUD	G7.GUD
G8.GUD	ACCESS.EXE	ASK.EXE	DISPLAY.EXE	COVER EXE
MAKEDATA.EXE	MENU.EXE	SPEED1.EXE	SPEED2.EXE	SPEED3.EXE
SPEED4.EXE	SPEED5.EXE	SPEED6.EXE	SPEED7.EXE	TERMINAT.EXE
AERATION.TPU	DEFDATA.TPU	DEFVALUE.TPU	DISINFC.TPU	FILTER.TPU
FLOCTION.TPU	HYDPROF1.TPU	HYDPROF2.TPU	HYDPROF3.TPU	MENUPROC.TPU
RAPIDMIX.TPU	SETTLING.TPU	SOFTNING.TPU	UNITSONE.TPU	

then displays MAIN-MENU (level-1) on the screen. Once the main menu is displayed the user has full freedom to design any unit in desired sequence. The option of the overview can be exercised at any time during the development of the chain of process and the user can continue with the design of more units in the same chain. A typical output of the package generated as a result of selection of sequence of units used in treatment of typical surface water to obtain drinking water is presented in Figures 4 - 10. This package has been tested on IBM PC compatible with EGA Graphics Card on a Colored Monitor and Hard Disk of 20 MB.

SUMMARY

The present thesis describes a package, WATREP I, developed for design of various units for water treatment. The package gives the hydraulic grade line of each unit along with conceptual orthographic projections of the units implemented. The package is implemented on IBM PC compatible using TURBO PASCAL VERSION 4.0.

In this version of the package all important and widely used treatment selections are possible. The unit selection process is aided with an information base which can be invoked to critically evaluate the suitability of one unit over other under a set of conditions. A schematic flow sheet can be visualized after completion of a design. To estimate the head loss and for laying of units at treatment plant, hydraulics option is made available.

The most important aspect, which still could not be completed is cost estimation of the treatment plant. The proposed approach for this requires generation of cost functions. Cost functions relates cost of a unit with most influential design parameter(s). This approach requires collection of cost data from previously constructed plants. Separate software packages which perform detailed structural design of units and estimated quantities of material can also be used for generating these data. Construction cost index can be used to find cost at any time.

The unit selection aid provided in the form of guidance can

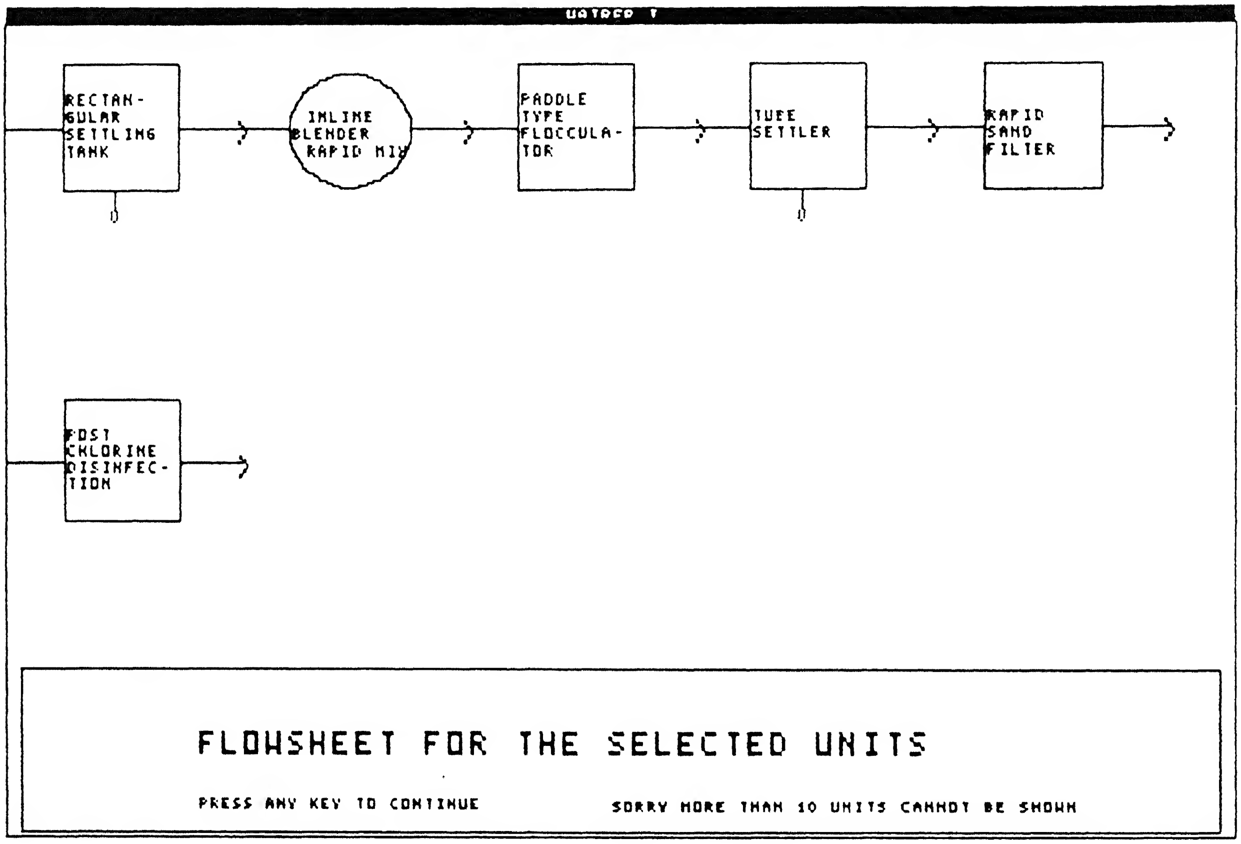
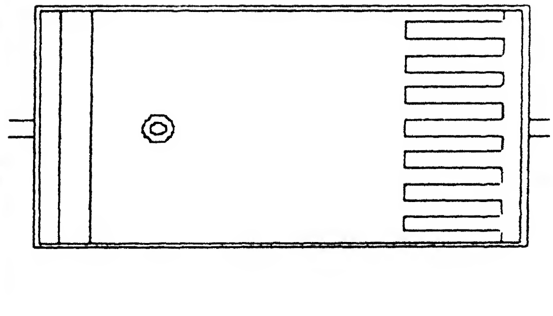


Figure 4. A Sample Flow Sheet Generated by Sequencing of Selected Units

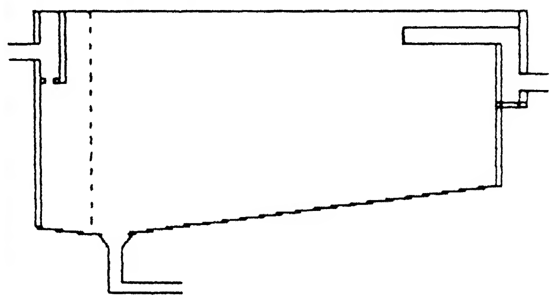
RECTANGULAR SETTLING TANK

Influent Discharge,cum/s:	1.0000
Surface Overflow Rate,m/s:	0.00928
Number of Tanks:	1
Width of Inffluent Channel,m:	0.64
Depth of Inffluent Channel,m:	0.75
Number of Ports:	19
Dia of ports,m:	0.469
Spacing of ports,m:	1.000
Width of Effluent Launder,m:	0.64
Depth of Effluent Launder,m:	1.40
No of Proj. Effl. Launders:	78
Depth of Proj.Effl.Launders,m:	0.26
Width of Proj.Effl.Launders,m:	0.34
Length of Outlet Zone,m:	3.35
Total Length of Tank,m:	21.62
Width of Tank,m:	6.43
Depth of Tank,m:	3.00
Bed Slope,%:	10.00

PRESS ANY KEY TO CONTINUE



PLAN



ELEVATION

WATREP I

HYDRAULIC PARAMETERS FOR RECTANGULAR SETT. TANK

(A).WATER SURFACE ELEVATIONS:

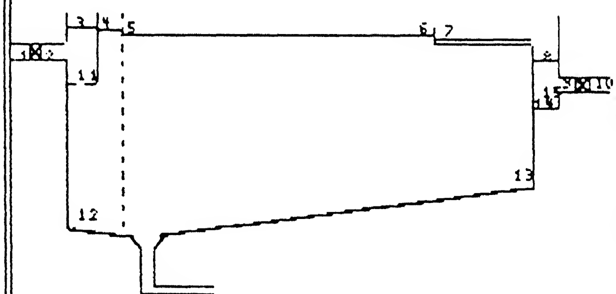
In Influent Channel(3):	111.53m
U/S of Baffle Wall(4):	111.52m
In Main Tank(5):	111.52m
In Proj. Effl. Launder(7):	111.47m
In Main Effl. Launder(8):	111.26m

(B).TOTAL HEADS IN M OF WATER:

U/S of Valve in Infl.Pipe(1):	111.54m
D/S of Valve in Infl.Pipe(2):	111.54m
U/S of Valve in Effl.Pipe(9):	110.50m
D/S of Valve in Effl.Pipe(10):	110.25m

(C).OTHER ELEVATIONS:

Tank Bottom Elevation(12):	108.53m
Infl.channel Bottom Elev.(11):	110.78m
Effl.Launder Bottom Elev.(7):	111.31m
Effl.Launder Bottom Elev.(14):	109.83m
Invert Level of Effl.Pipe(15):	111.26m
TOTAL HEADLOSS THRU THE UNIT:	1.29m
TOTAL HEAD REQ TILL THIS UNIT:	11.44m



HYDRAULIC FEATURES OF RECTANGULAR SETT. TANK

HYDRAULIC GRADIENT LINE THROUGH THE PLANT

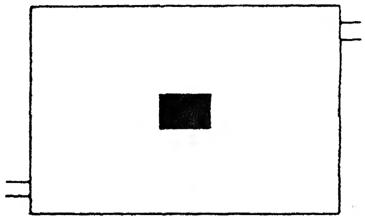
PRESS ANY KEY TO CONTINUE

Figure 5. A Sample Graphical Output of Rectangular Settling Tank for Presedimentation

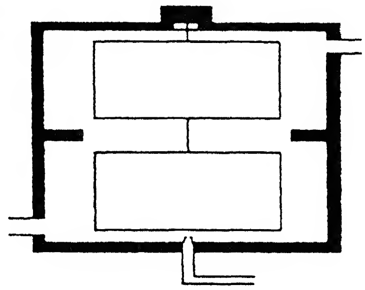
INLINE BLENDER RAPIDMIX

Influent Discharge,cum/sec:	1.0000
Temperature of Water,celsius:	25
Viscosity of Water,Kg/ms:	0.000970
Velocity Gradient,per sec:	1000
Number of Rapid Mixing Tank:	1
Length of Tank,m:	0.23
Width of Tank,m:	0.23
Depth of Tank,m:	0.47
Length of each Blade,m:	0.19
Height of each blade,m:	0.03
No of Blades :	4
Revolution per Min,RPM:	922
Motor Power required,Watts:	125.0

PRESS ANY KEY TO CONTINUE



PLAN



ELEVATION

WATFEP I

HYDRAULIC PARAMETERS FOR
INLINE BLENDER RAPID MIX

(A).WATER SURFACE ELEVATIONS:

In Main Body of Tank(4):	110.24m

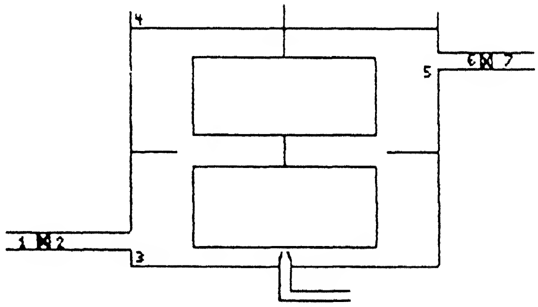
(B).TOTAL HEADS IN M OF WATER:

U/S of Valve in Infl.Pipe(1):	110.25m
D/S of Valve in Infl.Pipe(2):	110.24m
U/S of Valve in Effl.Pipe(6):	109.56m
D/S of Valve in Effl.Pipe(7):	109.22m

(C).OTHER ELEVATIONS:

Tank Bottom Elevation(3):	109.24m
Invert Level of Effl.Pipe(5):	106.96m

TOTAL HEADLOSS THRU THE UNIT:	1.02m
TOTAL HEAD REQ TILL THIS UNIT:	10.15m



HYDRAULIC FEATURES OF
INLINE BLENDER RAPID MIX

HYDRAULIC GRADIENT LINE THROUGH THE PLANT

PRESS ANY KEY TO CONTINUE

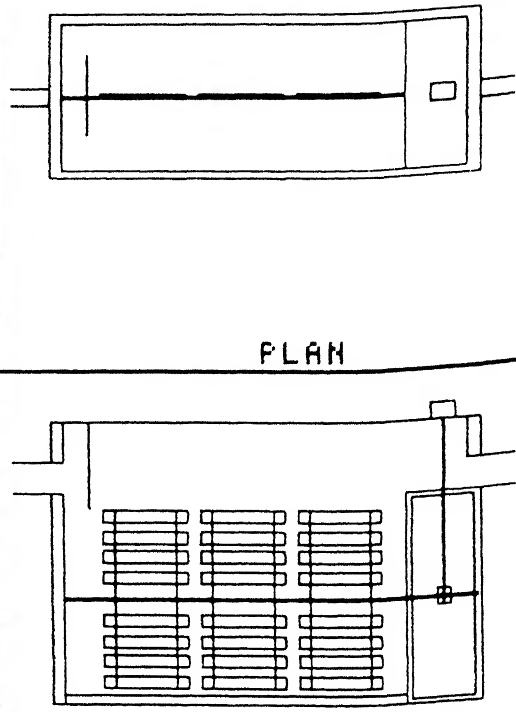
Figure 6. A Sample Graphical Output of Inline Blender for Rapid Mixing

WATREP I

PADDLE TYPE FLOCCULATOR

Influent Discharge,cum/sec:	1.0000
Water Temperature,deg celsius:	25
Velocity Gradient,per sec:	50
Number of Tanks:	8
Length of Tank,m:	10.43
Width of Tank,m:	3.46
Depth of Tank,m:	3.46
Shaft Revolution per Min:	2
Number of Shafts:	2
Length of Shaft,m:	5.21
Diameter of Outer Paddles,m:	2.15
Length of Paddles,m:	5.21
Spacing of Paddles,m:	0.10
Width of Paddles,m:	0.13
Paddles on Each Side of Shaft:	2
Motor Power required,Watts:	378.7
Power Input required,Watts:	302.98

PRESS ANY KEY TO CONTINUE



WATREP I

HYDRAULIC PARAMETERS FOR
PADDLE TYPE FLOCCULATOR

(A).WATER SURFACE ELEVATIONS:

U/S of baffle wall(4):	109.20m
In main tank(5):	109.20m

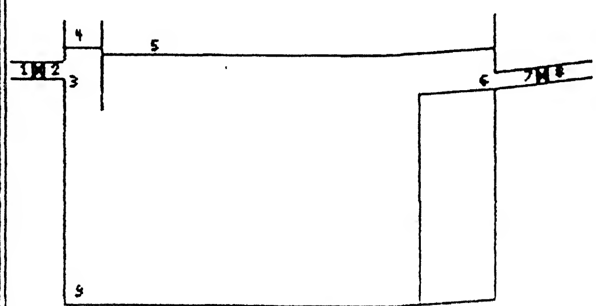
(B).TOTAL HEADS IN M OF WATER:

U/S of valve in infl. pipe(1):	109.22m
D/S of valve in infl. pipe(2):	109.22m
U/S of valve in effl. pipe(7):	108.52m
D/S of valve in effl. pipe(8):	108.18m

(C).OTHER ELEVATIONS:

Invert level of effl. pipe(6):	105.92m

TOTAL HEADLOSS THRU THE UNIT:	1.04m
TOTAL HEAD REQ TILL THIS UNIT:	9.12m



HYDRAULIC FEATURES OF PADDLE TYPE FLOCCULATOR

HYDRAULIC GRADIENT LINE THROUGH THE PLANT

PRESS ANY KEY TO CONTINUE

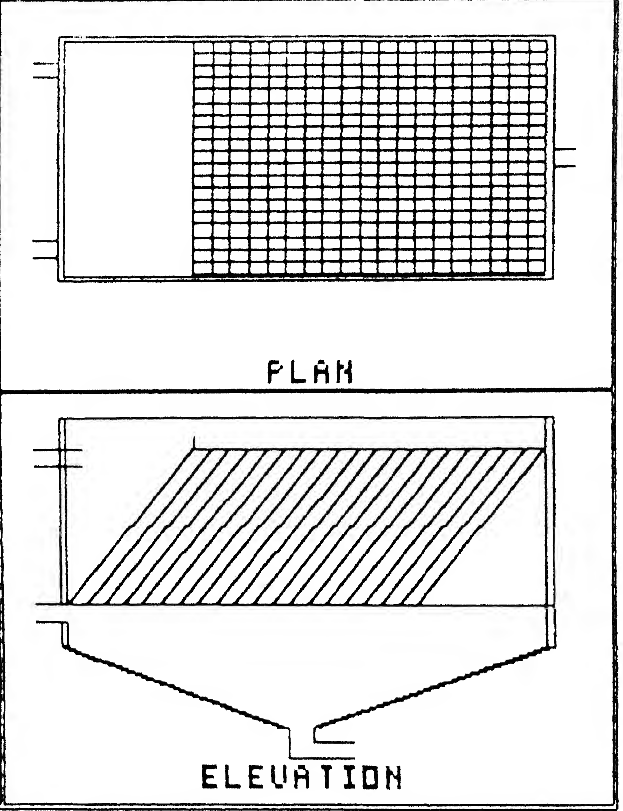
Figure 7. A Sample Graphical Output of Paddle Flocculator for Flocculation

WATREP I

TUBE SETTLER

Influent Discharge,cum/s:	1.0000
Number of Tanks	2
Length of Tank,m:	48.77
Width of Tank,m:	3.00
Height of Tank,m:	3.27
Flow Vel.through Tubes,m/s:	0.0050
Length of Tube,m:	1.55
Width of Tube,m:	0.05
Thickness of Tube:,m	0.0050
Inclination from Horiz,Degrees:	60.00
Total no of Tubes:	40000
Number of Tubes in One Row:	50
Number of Tubes in One Column:	800

PRESS ANY KEY TO CONTINUE



WATREP I

HYDRAULIC PARAMETERS FOR
TUBE SETTLER

(A).WATER SURFACE ELEVATIONS:

Over the Tubes(3):	108.18m
In Outlet Portion(5):	107.59m

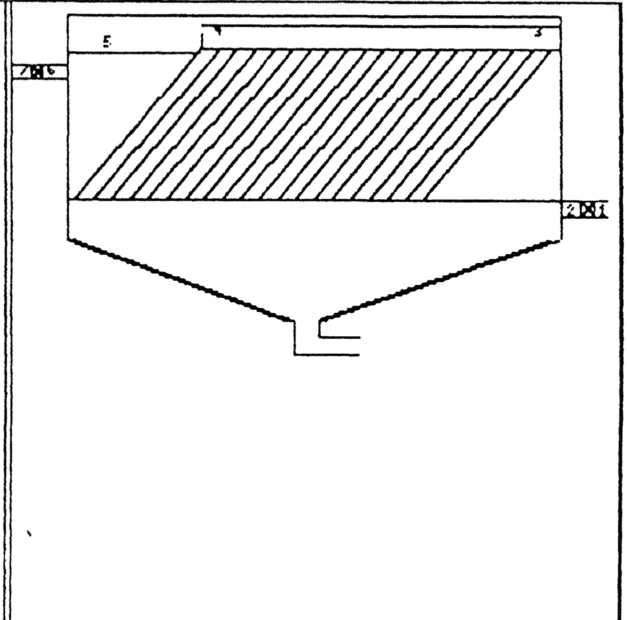
(B).TOTAL HEADS IN M OF WATER:

U/S of Valve in Infl.Pipe(1):	108.18m
D/S of Valve in Infl.Pipe(2):	108.18m
U/S of Valve in Effl.Pipe(6):	106.91m
D/S of Valve in Effl.Pipe(7):	106.57m

(C).OTHER ELEVATIONS:

Weir Top Elevation(4):	107.64m

TOTAL HEADLOSS THRU THE UNIT:	1.61m
TOTAL HEAD REQ TILL THIS UNIT:	8.08m



HYDRAULIC FEATURES OF
TUBE SETTLER

HYDRAULIC GRADIENT LINE THROUGH THE PLANT

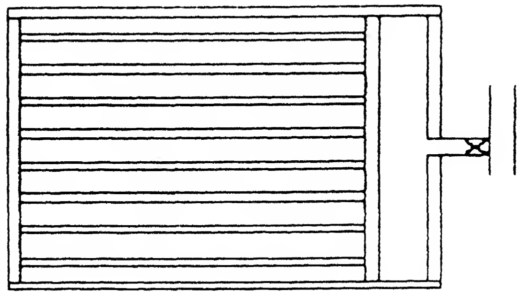
PRESS ANY KEY TO CONTINUE

Figure 8. A Sample Graphical Output of Tube Settler for Post Flocculation Settling

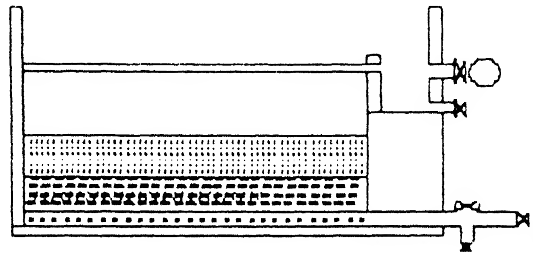
RAPID SAND FILTER

No of filter beds:	28
Width of each filter bed,m:	5.00
Length of each filter bed,m:	6.75
Depth of each filter bed,m:	2.76
Diameter of laterals,m:	0.063
Spacing of laterals,m:	0.40
Depth of sand bed,m:	1.00
Depth of gravel bed,m:	0.45
Diameter of main,m:	0.314
No of orifices per lateral:	6
Diameter of orifices,m:	0.018
Spacing of orifices,m:	0.400
Spacing of washwater troughs,m:	1.80
No of washwater troughs:	4.00
Width of washwater troughs,m:	0.200
Depth of washwater troughs,m:	0.121
Length of washwater tank,m:	1.73
Width of washwater tank,m:	1.73
Depth of washwater tank,m:	1.73
Influent discharge,cum/s:	1.0000

PRESS ANY KEY TO CONTINUE



PLAN



ELEVATION

WATREP I

HYDRAULIC PARAMETERS FOR
RAPID SAND FILTER

(A).WATER SURFACE ELEVATIONS:

Over the sand bed(5):	106.49m
In the infl. channel(3):	106.56m

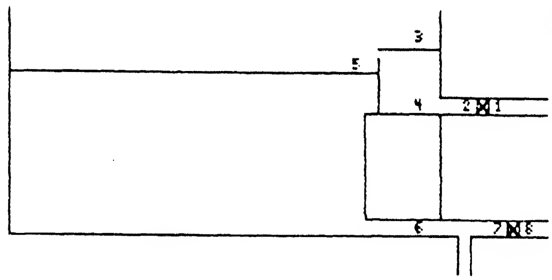
(B).TOTAL HEADS IN M OF WATER:

U/S of valve in infl.pipe(1):	106.57m
D/S of valve in infl.pipe(2):	106.57m
U/S of valve in effl.pipe(8):	103.54m
D/S of valve in effl.pipe(9):	103.21m

(C).OTHER ELEVATIONS:

Tank bottom elevation(6):	104.22m

TOTAL HEADLOSS THRU THE UNIT:	3.36m
TOTAL HEAD REQ TILL THIS UNIT:	6.47m



HYDRAULIC FEATURES OF
RAPID SAND FILTER

HYDRAULIC GRADIENT LINE THROUGH THE PLANT

PRESS ANY KEY TO CONTINUE

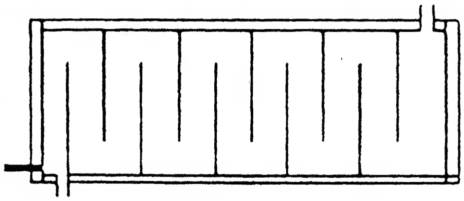
Figure 9. A Sample Graphical Output of Single Media High Rate Filter for Filtration

WATREF I

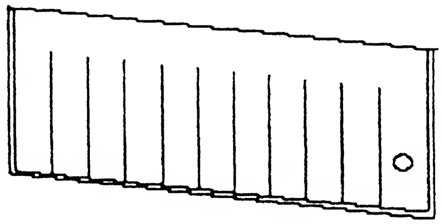
POST CHLORINATION

Influent Discharge,cum/s: 1.0000
Disinfectant Dose,g/l: 0.0142
Daily Disinfectant Req.,Kg: 1229.40
Hydraulic Retention Time,s: 5
Single Channel Length,m: 0.98
Channel Width,m: 0.10
Channel Depth,m: 0.49
Number of Channels,m: 100
Length of Tank,m: 9.77
Width of Tank,m: 0.98
Depth of Tank,m: 0.49
Height of Baffle,m: 0.49
Length of Baffle,m: 0.93

PRESS ANY KEY TO CONTINUE



PLAN



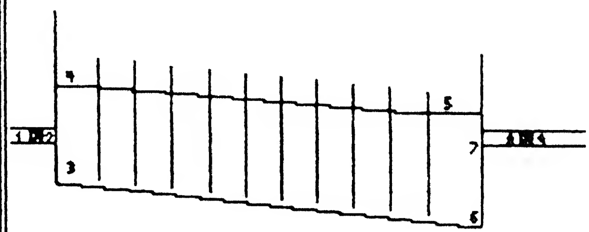
ELEVATION

WATREF I

HYDRAULIC PARAMETERS FOR
POST CHLORINATION
(A).WATER SURFACE ELEVATIONS:
In influent channel(4): 103.20m
In effluent channel(5): 100.22m

(B).TOTAL HEADS IN M OF WATER:
U/S of valve in infl. pipe(1):103.21m
D/S of valve in infl. pipe(2):103.20m
U/S of valve in effl. pipe(8):100.20m
D/S of valve in effl. pipe(9):100.20m
(C).OTHER ELEVATIONS:
Infl. channel bottom elev.(3):102.71m
Effl. channel bottom elev.(6): 99.73m
Invert level of Effl. pipe(7):100.20m

TOTAL HEADLOSS THRU THE UNIT: 3.01m
TOTAL HEAD REQ TILL THIS UNIT: 3.11m



HYDRAULIC FEATURES OF
POST CHLORINATION

HYDRAULIC GRADIENT LINE THROUGH THE PLANT
PRESS ANY KEY TO CONTINUE

Figure 10. A Sample Graphical Output of Chlorinator for Post Disinfection

be rationalized if the feed back from plants in operation and their performance history can be built into the package as a knowledge base. This information can be used to express any parameter related to the units in the form of a single number. An expert system then can be builtin to automatically arrive at most suited units taking user defined conditions as input. This, however, requires a vast database to get reliable results and of course tremendous logical and storage capabilities to include almost all possible combinations of operating, climatic and other conditions.

An appropriately powerful drafting facility to user at the time of layout of plant units can enhance capability of such packages. This will allow user to fix horizontal and vertical position of unit at the plant site.

A feedback of unusual design values in design of any unit should be given to the user along with suggestion(s) for their rectification. This is one of the most important requirement in the current package.

This package is basically prepared to serve the purpose of preliminary design of water treatment plants. Optimization, therefore is not suggested to be included in the package. However, once the preliminary design of the treatment plant is over, there should be packages available to perform detailed design of units which may or may not include optimization.

The separate software packages are more adaptable for inclusion of most of the minor details pertaining to treatment unit. A variety of influent and effluent structures can be used for various units. These software packages can be structured to include a variety of effluent and influent structures as options. The detailed design of units and their ancillary components will tend to produce more realistic hydraulic design and accurate head loss computations. These can be further extended to include design of various other components of treatment plants like flow splitter, flow collection box, etc. so that a complete detailed

design of units is possible.

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APPENDICES

APPENDIX I - TEXT OF GUIDE LINES

Level 0 - Main Menu:

WELCOME TO W A T R E P GUIDELINES
SELECTION OF THIS OPTION AT DIFFERENT LEVELS GIVES GUIDELINES FOR SUITABLE AND MOST APPROPRIATE SELECTION FROM OPTIONS AVAILABLE AT THAT LEVEL. GUIDELINE OPTION ITSELF IS A THREE TIER SYSTEM.

DESCRIBE
A BRIEF INFORMATION ON RELATIVE MERITS AND DEMERITS AND (UN)FAVORABLE CONDITIONS OF SELECTION OF UNIT.
PERFORM
DESIGN PARAMETER VALUES FOR THE UNITS AT APPROPRIATE LEVEL FOR THE OPTIONS AVAILABLE.
COMPARE
RATING OF UNITS AT THAT LEVEL WITH RESPECT TO THE SIGNIFICANT PARAMETERS

RATING LEVELS

0=>NIL	2=>VERY LOW	4=>LOW
6=>AVERAGE	8=>HIGH	10=>VERY HIGH
F=>VERY POOR	E=>POOR	D=>FAIR
C=>GOOD	B=>VERY GOOD	A=>EXCELLENT

NA: INFORMATION NOT AVAILABLE

N/A: NOT APPLICABLE

PLEASE MOVE TO ANY OF THE NEXT LEVELS

DESCRIBE

1. INTAKE: CHOOSE THIS OPTION FOR THE DESIGN OF INTAKE STRUCTURES FROM THE OPTIONS RIVER, RESERVOIR AND GROUND WATER.

2. PUMPING: CHOOSE THIS OPTION FOR SELECTING PUMPS FROM TWO OPTIONS: PUMPING WATER OR SLUDGE.

3. AERATION: SELECT THIS OPTION FOR AERATION OF WATER FOR FOLLOWING REASONS:-

A. TO ADD OXYGEN TO WATER FOR IMPARTING FRESHNESS.

B. TO EXPEL CARBON DIOXIDE, HYDROGEN SULFIDE AND VOLATILE SUBSTANCES MAINLY ORGANICS CAUSING TASTE AND ODOR.

C. TO PRECIPITATE IMPURITIES LIKE IRON AND MANGANESE.

SELECT THIS OPTION BEFORE PRESETTLING, COAGULATION OR FILTRATION.

4. SETTLING: SELECT THIS OPTION BEFORE OR AFTER COAGULATION AND PRECIPITATION TO SEPARATE THE SUSPENDED SOLIDS FROM WATER. SETTLING IS USED TO REMOVE READILY SETTLING SEDIMENTS SUCH AS SAND AND SILT, COAGULATED IMPURITIES SUCH AS COLOR AND TURBIDITY AND PRECIPITATED IMPURITIES SUCH AS HARDNESS AND IRON.

5. FEEDING TANK: SELECT THIS OPTION FOR DESIGN OF DOSING TANKS USED FOR STORING CHEMICAL FEED IN THE FORM OF SOLUTION AND MIXING INTO WATER.

6. RAPID MIX: SELECT THIS OPTION FOR RAPIDLY AND UNIFORMLY MIXING COAGULANTS AND CHEMICALS THROUGHOUT MASS OF WATER. THIS HELPS IN FORMATION OF MICROFLOCS AND RESULTS IN PROPER UTILIZATION OF A CHEMICAL COAGULANT PREVENTING LOCALIZATION OF CONCENTRATION AND PREMATURE FORMATION OF HYDROXIDES WHICH LEADS TO LESS EFFECTIVE UTILIZATION OF THE COAGULANT. THE SOURCE OF POWER FOR RAPID MIXING ARE GRAVITATIONAL, MECHANICAL AND PNEUMATIC. USE THIS OPTION BEFORE FLOCCULATION, CLARIFLOCCULATION, SOFTENING AND/OR DISINFECTION.

7. FLOCCULATION: USE THIS OPTION FOR DESIGN OF FLOCCULATION UNITS. SELECT THIS OPTION BEFORE SOFTENING, FILTRATION, DISINFECTION. IN FLOCCULATION THE HYDRODYNAMIC PROCESS OF SLOW MIXING RESULTS IN FORMATION OF LARGE AND READILY SETTLEABLE FLOCS BY BRINGING THE FINELY DIVIDED MATTER INTO CONTACT WITH THE MICROFLOCS FORMED DURING RAPID MIXING. THESE CAN BE SUBSEQUENTLY REMOVED IN SETTLING TANKS.

8. CLARRIFLOCULAION: USE THIS OPTION FOR COMBINED COAGULATION, FLOCCULATION AND SETTLING.

9. SOFTENING: USE THIS OPTION TO REMOVE HARDNESS. THE PURPOSE OF SOFTENING IS TO REDUCE THE SOAP CONSUMING PROPERTIES, REDUCE SCALING PROBLEMS IN HEATERS AND GEYSERS AND IMPROVE PALATABLY. WHEN HARDNESS IS LESS THAN 150 MG/L SOFTENING FOR DOMESTIC PURPOSES IS USUALLY NOT JUSTIFIED. OPTIONS AVAILABLE ARE CHEMICAL AND ION EXCHANGE. AFTER THIS OPTION CHOOSE RAPID MIX, FLOCCULATION, SETTLING AND/OR DISINFECTION.

10. FILTRATION: CHOOSE THIS OPTION FOR DESIGN OF FILTRATION UNITS FROM THE OPTIONS SLOW SAND, HIGH RATE AND PRESSURE. USE THIS OPTION FOR SEPARATING OUT SUSPENDED AND COLLOIDAL IMPURITIES FROM WATER BY PASSAGE THROUGH A POROUS BED. IT IS EMPLOYED FOR TREATMENT OF WATER TO EFFECTIVELY REMOVE TURBIDITY, COLOR, MICROORGANISMS, PRECIPITATED HARDNESS FROM CHEMICALLY SOFTENED WATERS AND PRECIPITATED IRON AND MANGANESE FROM AERATED WATERS. SELECT THIS OPTION AFTER FLOCCULATION AND SETTLING OR SOFTENING AND SETTLING. CHOOSE DISINFECTION AFTER THIS OPTION.

11. DISINFECTION: CHOOSE THIS OPTION FOR DESIGN OF DISINFECTION UNITS. SELECT THIS OPTION FOR ENSURING THAT PATHOGENS AND OTHER MICROORGANISMS ARE INACTIVATED. BACTERIA, VIRUSES AND AMOEBIC CYSTS CONSTITUTE THE THREE MAIN TYPES OF HUMAN ENTERIC PATHOGENS AND EFFECTIVE DISINFECTION IS AIMED AT DESTRUCTION OR INACTIVATION OF THESE AND OTHER PATHOGENS SUCH AS HELMINTHS RESPONSIBLE FOR WATER BORNE DISEASES. THE NEED FOR DISINFECTION IN ENSURING

PROTECTION AGAINST TRANSMISSION OF WATER BORNE DISEASES CANNOT BE OVER EMPHASIZED AND ITS INCLUSION AS ONE OF THE WATER TREATMENT PROCESSES IS CONSIDERED NECESSARY. USE THIS OPTION FOR PRE (BEFORE COAGULATION - FLOCCULATION OR FILTRATION) AND POST DISINFECTION (LAST UNIT OPERATION IN THE WATER TREATMENT).

12. ADVANCE PROCESSES: USE THIS OPTION FOR PRODUCTION OF ULTRA PURE WATER AND TREATMENT OF SALINE WATER. THIS OPTION SHOULD BE CHOSEN AFTER EACH OF ABOVE OPTIONS.

13. OVERVIEW: SELECT THIS OPTION AFTER THE ABOVE OPTIONS FOR FLOW SHEET GENERATION, HYDRAULIC GRADE LINE, DISPLAY AND SAVING OF DIAGRAMS AND TO DETERMINE APPROXIMATE COST OF TREATMENT PLANT.

14. GUIDELINES: SELECT THIS OPTION FOR VIEWING THE ABOVE INFORMATION.

15. ESCAPE: SELECT THIS OPTION FOR GOING TO PREVIOUS LEVEL (MENU).

Level 1 - Intake Menu:

DESCRIBE

RIVER: USE THIS OPTION WHEN SOURCE OF RAW WATER IS RIVER, STREAM OR SPRINGS. WATERS FROM RIVERS, STREAMS AND CANALS ARE GENERALLY MORE VARIABLE IN QUALITY AND LESS SATISFACTORY THAN THOSE FROM LAKES AND IMPOUNDED RESERVOIRS. STREAMS FROM SPARSELY INHABITED WATERSHEDS WOULD CARRY SUSPENDED IMPURITIES FROM ERODED CATCHMENTS, ORGANIC DEBRIS AND MINERAL SALTS. IN POPULATED REGIONS POLLUTION BY SEWAGE AND INDUSTRIAL WASTES WILL BE DIRECT.

RESERVOIR: USE THIS OPTION WHEN SOURCE OF RAW WATER IS RESERVOIR. IMPOUNDING RESERVOIRS FORMED BY HYDRAULIC STRUCTURES THROWN ACROSS RIVER VALLEYS, ARE SUBJECT, MORE OR LESS, TO THE SAME CONDITIONS AS NATURAL LAKES AND PONDS. WHILE TOP LAYERS OF WATER ARE PRONE TO DEVELOP ALGAE, BOTTOM LAYERS OF WATER MAY BE HIGH IN TURBIDITY, CARBON DIOXIDE, IRON, MANGANESE AND ON OCCASIONS, HYDROGEN

SULPHIDE.

GROUND WATER: USE THIS OPTION WHEN RAW WATER IS BEING TAKEN FROM UNDER GROUND. GENERALLY GROUND WATERS ARE CLEAR AND COLORLESS BUT ARE HARDER THAN SURFACE WATERS OF THE REGION IN WHICH THEY OCCUR. BACTERIALLY, GROUND WATERS ARE MUCH BETTER THAN SURFACE WATERS EXCEPT WHERE SUB SURFACE POLLUTION EXISTS.

GUIDELINES: TO SEE DESCRIPTION, PERFORMANCE AND COMPARISON OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
COMPARE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

COMPARISON

DESCRIPTION	RIVER	RESERVOIR	GROUND WATER
1. CONSISTENCY IN WATER QUALITY	E	C	B
2. TOTAL HARDNESS	2	2 - 4	6 - 10
3. TURBIDITY	6 - 10	4 - 6	0 - 2
4. TOTAL DISSOLVED SOLIDS	2	4 - 6	6 - 10
5. TASTE	B	D	C
6. CHLORIDES	0 - 4	2 - 6	6 - 8
7. BACTERIAL QUALITY	D	E	A
8. POWER CONSUMPTION	2 - 4	2 - 4	6 - 10

Level 1 - Pumping Menu:

DESCRIBE

WATER: USE THIS OPTION FOR PUMPING WATER TO AND THROUGH THE PLANT. PUMPING MACHINERY IS USED TO LIFT WATER FROM SOURCE TO PURIFICATION WORKS OR TO THE CLEAR WATER RESERVOIR, TRANSPORTING WATER THROUGH TREATMENT WORKS, DRAINING OF SETTLING TANKS AND OTHER TREATMENT UNITS, SUPPLYING WATER ESPECIALLY WATER UNDER PRESSURE TO OPERATING EQUIPMENT AND PUMPING CHEMICAL SOLUTIONS TO TREATMENT UNITS.

SLUDGE: USE THIS OPTION FOR PUMPING SLUDGE PRODUCED IN VARIOUS UNIT OPERATIONS IN THE PLANT.

GUIDELINES: TO SEE DESCRIPTION, PERFORMANCE AND COMPARISON OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
COMPARE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

COMPARISON

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
PERFORMANCE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

Level 1 - Aeration Menu:

DESCRIBE

DIFFUSED: USE THIS OPTION FOR DESIGN OF DIFFUSED AERATION SYSTEM WITH NOZZLE DIFFUSERS. THIS UNIT CONSISTS OF NOZZLES AND PIPES IN A BASIN IN WHICH COMPRESSED AIR IS INJECTED TO RISE THROUGH WATER BEING AERATED. AS THE RISING BUBBLES OF AIR HAVE A LOWER AVERAGE VELOCITY THAN THE FALLING OF DROPS THIS UNIT PROVIDES A LONGER AERATION PERIOD THAN THE CASCADE TYPE FOR THE SAME HEAD LOSS. THESE HAVE HIGHER INITIAL COSTS AND REQUIRE GREATER RECURRING EXPENDITURE. THEY REQUIRE LESS SPACE THAN SPRAY AERATORS AND COLD WEATHER OPERATING PROBLEMS ARE NOT ENCOUNTERED.IT IS LESS POPULAR IN WATER TREATMENT PLANTS AS COMPARED TO OTHER OPTIONS.

CASCADE: USE THIS OPTION FOR DESIGN OF CASCADE AERATOR IN WHICH WATER IS ALLOWED TO FLOW DOWNWARDS IN A SERIES OF FALLS TO PRODUCE TURBULENCE. IT ADDS TO THE BEAUTY OF PLANT. HEAD LOSS IS GREATER THAN OTHER OPTIONS. IN COLD CLIMATES THESE AERATORS MUST BE HOUSED WITH ADEQUATE PROVISION FOR VENTILATION. CORROSION AND SLIME PROBLEMS MAY BE ENCOUNTERED IN AERATED WATER.

SPRAY: USE THIS OPTION FOR DESIGN OF SPRAY AERATION SYSTEM IN WHICH WATER IS SPRAYED THROUGH NOZZLES UPWARD INTO THE ATMOSPHERE IN THE FORM OF FOUNTAIN AND BROKEN UP INTO EITHER MIST OR DROPLETS. WATER IS DIRECTED AT A SLIGHT INCLINATION TO THE

VERTICAL. THE INSTALLATION CONSISTS OF TRAYS AND FIXED NOZZLES ON A PIPE GRID WITH NECESSARY OUTLET ARRANGEMENTS.

GUIDELINES: SELECT THIS OPTION TO SEE DESCRIPTION, PERFORMANCE AND COMPARISON OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	DIFFUSED	CASCADE	SPRAY
1. CARBON DIOXIDE REMOVAL %	40-75%	20-45%	70-90%
2. HYDROGEN SULFIDE REMOVAL%	50-80%	20-35%	90-99%
3. VOLATILE ORGANICS REMOVAL	NA	NA	NA
4a. PRECIPITATION OF IRON	NA	NA	NA
4b. PRECIPITATION OF MANGANESE	NA	NA	NA
5. PRESSURE REQUIRED AT NOZZLE IN METERS OF WATER	~5	N/A	~7
6. AERATOR AREA, SQM/KLD	N/A	0.5 - 0.65	0.00125 - 0.00375
7. AIR REQUIRED CUM/KL	0.6 - 1.5	N/A	N/A
8. POWER REQUIRED WATT/KL	3 - 10	N/A	N/A
9. HEAD LOSS, IN M OF WATER	N/A	0.5 - 0.30	8 - 10

COMPARISON

DESCRIPTION	DIFFUSED	CASCADE	SPRAY
1. GAS TRANSFER EFFICIENCY	6	4	8
2. EFFICIENCY IN COLD CLIMATE	8	2	4
3. FREEDOM FROM MANUFACTURERS PATENTS	E	B	D
4. SKILLED PERSON REQUIREMENT	4 - 6	2	4 - 6
5. INITIAL COST	8	4 - 6	6 - 8
6. MAINTENANCE COST	8	2 - 4	4 - 6
7. EXTENT OF USE	2	6	8

Level 1 - Settling Menu:

DESCRIBE

HIGH RATE: USE THIS OPTION FOR DESIGN OF TUBE SETTLERS AND PLATE SETTLERS.THESE HAVE HIGHER EFFICIENCY. USE OF HIGH RATE SETTLERS CAN REDUCE DETENTION TIME TO FEW MINUTES. THESE UNITS ACHIEVE BETTER EFFICIENCY AND ECONOMY IN SPACE AS WELL AS COST.

CONVENTIONAL: USE THIS OPTION FOR DESIGN OF CONVENTIONAL SETTLING LIKE RECTANGULAR AND CIRCULAR SETTLING TANK. IN THESE TYPE OF TANKS DIRECTION OF FLOW IS SUBSTANTIALLY HORIZONTAL. SLUDGE IS REMOVED BY MECHANICAL SCRAPERS.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	CONVENTIONAL	HIGH RATE
1. HYDRAULIC RETENTION TIME, HOUR	1 - 8	0.2 - 0.8
2. WEIR LOADING, M/DAY	150 - 300	600 - 1200
3. SURFACE OVERFLOW RATE, M/DAY	15 - 60	96 - 144
4. DEPTH OF TANK, M	3 - 7	3 - 10

COMPARISON

DESCRIPTION	CONVENTIONAL	HIGH RATE
1. FREEDOM FROM STREAMING AND OVERTURN	8	4
2. EFFICIENCY WITH HEAVILY SILTED WATERS	8	4
3. EFFICIENCY IN VARIABLE INFLUENT QUALITY	8	4 - 6
4. EFFECTIVENESS WITH ALGAE	C	E
5. SUITABILITY FOR IRON REMOVAL	C	E
6. SUITABILITY FOR LIME SOFTENING	C	E
7. EFFECTIVENESS ON SMALL SCALE	D	B
8. EFFECTIVENESS ON BIG WORKS	B	B
9. ADVANTAGEOUS USE OF LAND	E	B
10. EASE OF CLEANING	B	E
11. FREEDOM FROM MANUFACTURERS PATENTS	B	E
12. SKILLED PERSON REQUIREMENT	4	8
13. OVERALL COST	4	6
14. EXTENT OF USE	8	2

Level 2 - Settling --> High Rate Menu:

DESCRIBE

TUBES: USE THIS OPTION FOR DESIGN OF TUBE SETTLERS WHICH ARE RECENT TECHNOLOGY DEVICES TO REDUCE SEDIMENTATION COSTS BY INCREASING THE EFFECTIVE SURFACE AREA OF CONVENTIONAL SEDIMENTATION TANKS AND LIQUID RETENTION TIME. THESE PROVIDE EXCELLENT CLARIFICATION FOR DETENTION TIMES LESS THAN 10 MIN. THESE UNITS CONSIST OF TUBE SETTLER MADE OF PREFABRICATED THIN BLACK SHEETS 1 M LING OF PVC, TIMBER, ASBESTOS CEMENT ETC.

PLATES: USE THIS OPTION FOR DESIGN OF PLATE SETTLER UNITS. PARALLEL PLATES ARE USUALLY INTRODUCED TO ENHANCE THE EFFICIENCY OF EXISTING CONVENTIONAL RECTANGULAR SETTLING BASINS. AS SUCH BOTH TUBE AND PLATE SETTLER ARE EQUIVALENT OPTIONS.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	TUBES	PLATE
1. HYDRAULIC RETENTION TIME, HOUR	0.2 - 0.8	0.5 - 1.0
2. WEIR LOADING, M/DAY	800 - 1200	600 - 1000
3. SURFACE OVERFLOW RATE, M/DAY	100 - 144	96 - 120
4. INCLINATION FROM HORIZONTAL OF PLATES/TUBES, DEGREES	5 - 60	5 - 60
5. FLOW VELOCITY THROUGH TUBES/PLATES, M/S	0.003 - 0.006	0.003 - 0.005

COMPARISON

DESCRIPTION	TUBES	PLATES
1. FREEDOM FROM STREAMING AND OVERTURN	4	4
2. EFFICIENCY WITH HEAVILY SILTED WATERS	6	6
3. EFFICIENCY IN VARIABLE INFLUENT QUALITY	6	8
4. EFFECTIVENESS WITH ALGAE	E	E
5. SUITABILITY FOR IRON REMOVAL	D	D
6. SUITABILITY FOR LIME SOFTENING	D	C
7. EFFECTIVENESS ON SMALL SCALE	B	B
8. EFFECTIVENESS ON BIG WORKS	B	B
9. ADVANTAGEOUS USE OF LAND	B	B
10. EASE OF CLEANING	E	D
11. FREEDOM FROM MANUFACTURERS PATENTS	D	D
12. SKILLED PERSON REQUIREMENT	6	4
13. OVERALL COST	6	4
14. EXTENT OF USE	4	2

Level 2 - Settling --> Conventional Menu:

DESCRIBE

RECTANGULAR: USE THIS OPTION FOR DESIGN OF RECTANGULAR SETTLING TANKS. IT IS LITTLE DIFFICULT TO CONSTRUCT AND ANALYZE STRUCTURALLY. SLUDGE SCRAPERS REQUIRE ARRANGEMENT OF ADJUSTABLE ARMS TO REACH CORNER POINTS OF TANK. MULTIPLE UNIT CONSTRUCTION MAY LEAD TO ECONOMY DUE TO COMMON WALLS. FOR SAME AREA IT GIVES LESS WEIR LOADING THAN CIRCULAR SHAPED SETTLING TANKS.

CIRCULAR: USE THIS OPTION FOR DESIGN OF CIRCULAR SETTLING TANKS. IT IS EASY TO CONSTRUCT AND ANALYZE STRUCTURALLY. SIMPLE SLUDGE SCRAPERS ARE REQUIRED. MAY NOT BE ECONOMICAL IN CASE MULTIPLE UNITS ARE REQUIRED. OPTIONS AVAILABLE ARE RADIAL FLOW AND CIRCUMFERENTIAL FLOW.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	RECTANGULAR	CIRCULAR
1. HYDRAULIC RETENTION TIME, HOUR	3 - 8	1 - 2.5
2. WEIR LOADING, M/DAY	150 - 200	150 - 600
3. SURFACE OVERFLOW RATE, M/DAY	10 - 60	25 - 75
4. DEPTH OF TANK, M	4 - 7	3 - 5
5. LENGTH/DIAMETER OF TANK, M	5 - 100	5 - 60
6. LENGTH TO WIDTH RATIO	3 - 5	N/A

COMPARISON

DESCRIPTION	RECTANGULAR	CIRCULAR
1. FREEDOM FROM STREAMING AND OVERTURN	8	8
2. EFFICIENCY WITH HEAVILY SILTED WATERS	8	6
3. EFFICIENCY IN VARIABLE INFLUENT QUALITY	8	6
4. EFFECTIVENESS WITH ALGAE	C	B
5. SUITABILITY FOR PRESEDIMENTAION	B	C
6. SUITABILITY FOR LIME SOFTENING	C	B
7. EFFECTIVENESS ON SMALL SCALE	D	D
8. EFFECTIVENESS ON BIG WORKS	B	B
9. ADVANTAGEOUS USE OF LAND	D	C
10. EASE OF CLEANING	B	C
11. FREEDOM FROM MANUFACTURERS PATENTS	B	C
12. SKILLED PERSON REQUIREMENT	.	6
13. OVERALL COST	6	8
14. EXTENT OF USE	8	6

evel 3 - Settling --> Conventional --> Circular Menu:

DESCRIBE

RADIAL FLOW: USE THIS OPTION FOR DESIGN OF RADIAL FLOW CIRCULAR SETTLING TANKS. IN THIS UNIT INFLUENT IS FED THROUGH CENTER AND FLOW APPROACHES HORIZONTAL FLOW. EFFLUENT IS COLLECTED BY EFFLUENT LAUNDER AT CIRCUMFERENCE.

CIRCUMFERENTIAL FLOW: USE THIS OPTION FOR DESIGN OF CIRCUMFERENTIAL FLOW CIRCULAR SETTLING TANK. IN THIS UNIT INFLUENT ENTERS THROUGH BOTTOM OF RIM OR CIRCUMFERENCE OF THE TANK AND EFFLUENT IS ALSO COLLECTED AT TOP OF RIM OR CIRCUMFERENCE OF TANK. THE FLOW APPROACHES TO VERTICAL FLOW.

GUIDELINES: TO SEE DESCRIPTION, PERFORMANCE AND COMPARISON OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	RADIAL FLOW	CIRCUMFERENTIAL FLOW
1. HYDRAULIC RETENTION TIME, HOUR	2 - 2.5	1 - 1.5
2. WEIR LOADING, M/DAY	200 - 500	300 - 600
3. SURFACE OVERFLOW RATE, M/DAY	25 - 75	40 - 50
4. DEPTH OF TANK, M	4 - 5	4 - 6
5. DIAMETER OF TANK, M	5 - 60	5 - 30
6. DIAMETER TO DEPTH RATIO	1 - 20	1 - 10

COMPARISON

DESCRIPTION	RADIAL FLOW	CIRCUMFERENTIAL FLOW
1. FREEDOM FROM STREAMING AND OVERTURN	6	4
2. EFFICIENCY WITH HEAVILY SILTED WATERS	6	4
3. EFFICIENCY IN VARIABLE INFLUENT QUALITY	6	6
4. EFFECTIVENESS WITH ALGAE	D	B
5. SUITABILITY FOR PRESEDIMENTAION	C	D
6. SUITABILITY FOR CHEMICAL SOFTENING	C	C
7. EFFECTIVENESS ON SMALL SCALE	D	D
8. EFFECTIVENESS ON BIG WORKS	B	B
9. ADVANTAGEOUS USE OF LAND	D	D
10. EASE OF CLEANING	B	C
11. FREEDOM FROM MANUFACTURERS PATENTS	C	C
12. SKILLED PERSON REQUIREMENT	4	6
13. OVERALL COST	6	8
14. EXTENT OF USE	6	4

evel 1 - Rapid Mix Menu:

DESCRIBE

MECHANICAL: USE THIS OPTION FOR SELECTING MECHANICAL UNITS FOR RAPID MIXING. THESE ARE MOST COMMONLY USED FOR RAPID MIXING. THE MECHANICAL UNITS ARE EFFICIENT AS THEY HAVE LITTLE HEAD LOSS AND ARE UNAFFECTED BY VOLUME OF FLOW OR FLOW VARIATIONS. BEST SUITED FOR PLANTS WHERE HEAD LOSS THROUGH THE PLANT IS TO BE CONSERVED AS MUCH AS POSSIBLE AND WHERE THE FLOW EXCEEDS 300 CUM/HR. HOWEVER, THESE UNITS REQUIRE EXTERNAL POWER.

NONMECHANICAL: USE THIS OPTION FOR SELECTING HYDRAULIC JUMP FOR BAFFLED CHANNELS FOR RAPID MIXING. THESE UNITS ARE SIMPLE TO CONSTRUCT BUT DO NOT GIVE FLEXIBILITY. NO MECHANICAL EQUIPMENT IS NEEDED TO OPERATE AND MAINTAIN. IN THESE UNITS HEAD LOSS IS APPRECIABLE. THESE ARE RELATIVELY LESS SUITABLE BECAUSE THEY HAVE EXCELLENT PLUG FLOW AND POOR MIXED FLOW CHARACTERISTICS. IN THESE DEVICES, THE REQUIRED TURBULENCE IS OBTAINED FROM THE FLOW OF WATER UNDER GRAVITY OR PRESSURE.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	MECHANICAL	NONMECHANICAL
1. HYDRAULIC RETENTION TIME, SEC	10 - 120	10 - 100
2. VELOCITY GRADIENT, PER SEC	750 - 5000	800 - 4000
3. POWER REQUIRED, WATT/CUM/HR	1 - 3	N/A
4. HEAD LOSS, M OF WATER	N/A	0.3 - 5

COMPARISON

DESCRIPTION	MECHANICAL	NONMECHANICAL
1. EFFICIENCY WITH VARIABLE INFLUENT QUANTITY	10	4
2. EFFECTIVENESS ON SMALL SCALE	B	B
3. EFFECTIVENESS ON BIG WORKS	B	D
4. ADVANTAGEOUS USE OF LAND	B	E
5. FREEDOM FROM MANUFACTURERS PATENTS	E	A
6. SKILLED PERSON REQUIREMENT	8	4
7. OVERALL COST	8	4
8. EXTENT OF USE	8	4

Level 2 - Rapid Mix --> Mechanical Menu:

DESCRIBE

JET INJECTOR: USE THIS OPTION FOR SELECTING JET INJECTOR FOR RAPID MIXING. IN THIS UNIT CHEMICAL IS INTRODUCED THROUGH NOZZLES/HOLES AT A PRESSURE IN OPPOSITE DIRECTION OF FLOW. IT IS LESS USED DUE TO PLUGGING OF ORIFICES AND NON FLEXIBILITY OF THE UNIT.

INLINE BLENDER: USE THIS OPTION FOR SELECTING INLINE BLENDER FOR RAPID MIXING. THESE UNITS WERE DEVELOPED FOR A VERY RAPID INSTANTANEOUS MIXING OF CHEMICALS WITH A MINIMUM OF SHORT CIRCUITING. THESE ARE LESS EXPENSIVE THAN TURBINE TYPE. MOST SUITABLE FOR ADSORPTION DESTABLIZATION TYPE COLLOIDAL REACTIONS.

TURBINE TYPE: USE THIS OPTION FOR SELECTING TURBINE TYPE UNIT FOR MIXING. THESE UNITS COMPRISE OF FLAT BLADES ATTACHED TO A SHAFT ROTATING AT CONSIDERABLE RPM (100 RPM) WHICH GENERATES TURBULENCE AND CURRENT TO MIX THE CHEMICALS INSTANTANEOUSLY. THIS UNIT IS MORE COMMON FOR MIXING CHEMICALS AND COAGULANTS. MOST SUITABLE FOR SWEEP COAGULATION REACTIONS.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	JET	INLINE	TURBINE
1. VELOCITY GRADIENT G, 1/SEC	750-1000	3000-5000	700-1000
2. DETENTION TIME, SEC	1	1	50-120
3. SHAFT SPEED, RPM	N/A	NA	150-1500

COMPARISON

DESCRIPTION	JET	INLINE	TURBINE
1. AREA REQUIREMENT	4	8	10
2. POWER REQUIREMENT	6	6	8
3. EXTENT OF USE	6	6	8
4. FREEDOM FROM MANUFACTURERS PATENTS	E	E	E
5. HEAD LOSS	8	6	6
6. PERFORMANCE IN VARIABLE FLOW	D	B	B
7. OVERALL COST	4	6	8

el 2 - Rapid Mix --> Nonmechanical Menu:

DESCRIBE

BAFFLED: USE THIS OPTION FOR SELECTING BAFFLED UNITS FOR MIXING. IN THIS OPTION VERTICAL BAFFLE AND HORIZONTAL BAFFLED ARE IMPLEMENTED. BAFFLE PLATES CAN BE OF STEEL, WOOD OR CONCRETE. VELOCITY GRADIENTS ARE PURPOSELY INTENSIFIED BY ENFORCED CHANGES IN THE DIRECTION OF FLOW. IT IS A SIMPLE SYSTEM BUT IS NOT FLEXIBLE AND INVOLVES MUCH LOSS OF HEAD. THE DETENTION PERIOD IS

ALSO RESTRICTED AS OTHERWISE LONG CHANNELS ARE REQUIRED.

HYDRAULIC JUMP: CHOOSE THIS OPTION FOR DESIGN OF HYDRAULIC JUMP AS MIXING UNIT. IN THIS UNIT MIXING IS ACHIEVED BY A COMBINATION OF A CHUTE FOLLOWED BY A CHANNEL WITH OR WITHOUT SILL. LOSS OF HEAD IS APPRECIABLE AND DETENTION TIME IS ALSO VERY LOW. THIS UNIT THOUGH RELATIVELY INFLEXIBLE, IS SIMPLE AND CAN BE USED AS A STANDBY IN LARGE PLANTS TO THE MECHANICAL MIXERS WHILE FOR SMALL PLANTS, THIS CAN SERVE DIRECTLY AS THE MAIN UNIT.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	BAFFLED	HYDRAULIC JUMP
1. HYDRAULIC RETENTION TIME, SEC	10 - 30	3 - 10
2. VELOCITY GRADIENT, PER SEC	700 - 1000	600 - 12000
3. FLOW THROUGH VELOCITY, M/S	0.5 - 1.5	3 - 4
4. HEAD LOSS, M OF WATER	0.5 - 2.5	0.3 - 0.6

COMPARISON

DESCRIPTION	BAFFLED	HYDRAULIC JUMP
1. EFFICIENCY IN VARIABLE INFLUENT QUANTITY	2	2
2. EFFECTIVENESS ON SMALL SCALE	B	B
3. EFFECTIVENESS ON BIG WORKS	D	E
4. ADVANTAGEOUS USE OF LAND	E	C
5. FREEDOM FROM MANUFACTURERS PATENTS	A	A
6. SKILLED PERSON REQUIREMENT	4	6
7. OVERALL COST	8	6
8. EXTENT OF USE	6	4

Level 3 - Rapid Mix --> Nonmechanical --> Baffled Menu:

DESCRIBE

VERTICAL BAFFLED: USE THIS OPTION FOR SELECTING VERTICAL BAFFLED UNIT FOR RAPID MIXING. VELOCITY GRADIENTS ARE PURPOSELY INTENSIFIED BY ENFORCED CHANGES IN THE DIRECTION OF FLOW UPWARDS AND DOWNWARDS. IN THIS UNIT A HOMOGENEOUS MIXTURE OF THE SUSPENDED PARTICLES IS MAINTAINED DUE TO ALTERNATE RISE AND FALL OF WATER, WHICH PREVENTS DEPOSITION OF SLUDGE.

HORIZONTAL BAFFLED: USE THIS OPTION FOR SELECTING HORIZONTAL BAFFLED UNIT FOR RAPID MIXING. IT CONSISTS OF SERIES OF BAFFLES AROUND THE ENDS OF WHICH THE FLOWING WATER IS REVERSED IN DIRECTION, THUS CAUSING TURBULENCE AND AGITATION AT EACH POINT OF REVERSED FLOW. PROPER SCOURING ARRANGEMENTS HAVE TO BE MADE IN THIS UNIT TO PREVENT DEPOSITION OF SLUDGE.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	VERTICAL	HORIZONTAL
1. HYDRAULIC RETENTION TIME, SEC	10 - 30	10 - 30
2. VELOCITY GRADIENT, PER SEC	700 - 1000	800 - 1200
3. FLOW THROUGH VELOCITY, M/S	0.5 - 1.5	0.5 - 1.5
4. HEAD LOSS, M OF WATER	0.5 - 2.5	0.5 - 2.5

COMPARISON

DESCRIPTION	VERTICAL	HORIZONTAL
1. EFFICIENCY WITH VARIABLE INFLUENT QUANTITY	4	4
2. EFFECTIVENESS ON SMALL SCALE	B	B
3. EFFECTIVENESS ON BIG WORKS	D	D
4. ADVANTAGEOUS USE OF LAND	E	E
5. FREEDOM FROM MANUFACTURERS PATENTS	A	A
6. SKILLED PERSON REQUIREMENT	6	6
7. OVERALL COST	6	6
8. EXTENT OF USE	4	8

.evel 1 - Flocculation Menu:

DESCRIBE

MECHANICAL FLOCCULATION: USE THIS OPTION FOR SELECTING MECHANICAL FLOCCULATION UNITS INLINE BLENDER, PADDLE TYPE AND FLAT BLADE TURBINE. THESE ARE FLEXIBLE UNITS SINCE THE SPEED OF MECHANICAL BLADES OR PADDLES CAN BE ADJUSTED TO SUIT THE VARIATIONS IN FLOW, TEMPERATURE AND SILT CONDITIONS. THESE UNITS CONSIST OF REVOLVING PADDLES WITH HORIZONTAL OR VERTICAL SHAFT. THE PADDLES ARE DRIVEN BY MOTOR EITHER OF CONSTANT OR MULTIPLE SPEED OPERATING THROUGH A GEAR TYPE REDUCER OR DRIVE BELT CHAINS.

NONMECHANICAL FLOCCULATION: USE THIS OPTION FOR SELECTING NONMECHANICAL FLOCCULATION UNITS, BAFFLED AND GRAVITY FLOCCULATORS. THESE UNITS LACK FLEXIBILITY SINCE THE SYSTEM CAN BE DESIGNED FOR MAXIMUM EFFICIENCY ONLY AT ONE RATE OF FLOW AND AT ONE TEMPERATURE.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	MECHANICAL	NONMECHANICAL
1. HYDRAULIC RETENTION TIME, MIN	10 - 60	10 - 600
2. VELOCITY GRADIENT, PER SEC	10 - 100	20 - 75
3. FLOW THROUGH VELOCITY, M/S	0.2 - 0.8	0.10 - 0.30
3. POWER REQUIRED, WATT/CUM/HR	0.5 - 1.5	N/A
4. HEAD LOSS, M OF WATER	N/A	0.15 - 0.60

COMPARISON

DESCRIPTION	MECHANICAL	NONMECHANICAL
1. EFFICIENCY WITH VARIABLE INFLUENT QUANTITY	10	4
2. EFFECTIVENESS ON SMALL SCALE	B	B
3. EFFECTIVENESS ON BIG WORKS	B	D
4. ADVANTAGEOUS USE OF LAND	B	E
5. FREEDOM FROM MANUFACTURERS PATENTS	E	A
6. SKILLED PERSON REQUIREMENT	8	4
7. OVERALL COST	8	4
8. EXTENT OF USE	8	4

Level 2 - Flocculation --> Mechanical Menu:

DESCRIBE

INLINE BLENDER: USE THIS OPTION FOR SELECTING INLINE BLENDER FLOCCULATION UNIT. IT CONSISTS OF A ROTATING SHAFT WITH BLADES IN THE PASSAGE OF WATER. IT IS SIMILAR TO RAPID MIX UNIT. THE ONLY DIFFERENCE BEING THAT IN SPEED OF SHAFT. IN THIS UNIT THERE IS MINIMUM OF SHORT CIRCUITING. IT IS LESS EXPENSIVE THAN PADDLE AND

FLAT BLADE TURBINE TYPE.

PADDLE TYPE: USE THIS OPTION FOR SELECTING PADDLE TYPE FLOCCULATION UNITS. THE PADDLE TYPE DEVICES ARE MOUNTED HORIZONTALLY OR VERTICALLY AND ROTATE AT LOW SPEEDS 2 TO 15 RPM. THE CURRENTS GENERATED ARE BOTH RADIAL AND TANGENTIAL.

FLAT BLADE TURBINE: USE THIS OPTION FOR SELECTING FLAT BLADE TURBINE TYPE FLOCCULATION UNIT. IN THIS UNIT FLAT BLADES ARE CONNECTED TO A SHAFT. THE FLAT BLADES ARE IN THE SAME PLANE AS THE DRIVE SHAFT. THE BLADES CAN BE MOUNTED VERTICALLY OR HORIZONTALLY AND OPERATE AT 10 TO 15 RPM. THIS UNIT IS LEAST EFFECTIVE THAN ABOVE TWO UNITS.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	INLINE	PADDLE	TURBINE
1. HYDRAULIC RETENTION TIME, SEC	5 - 20	10 - 40	10 - 40
2. VELOCITY GRADIENT, 1/SEC	35 - 66	10 - 75	35 - 66
3. FLOW THROUGH VELOCITY, M/S	0.3 - 0.9	0.2 - 0.8	0.3 - 0.9
4. POWER REQUIRED, KW/MLD	6 - 25	10 - 36	6 - 30
5. SHAFT SPEED,RPM	2 - 10	2 - 15	5 - 10

COMPARISON

DESCRIPTION	INLINE	PADDLE	TURBINE
1. EFFICIENCY WITH VARIABLE INFLUENT QUANTITY	4	8	8
2. EFFECTIVENESS ON SMALL SCALE	B	B	B
3. EFFECTIVENESS ON BIG WORKS	B	B	B
4. ADVANTAGEOUS USE OF LAND	B	D	C
5. FREEDOM FROM MANUFACTURERS PATENTS	E	E	E
6. SKILLED PERSON REQUIREMENT	8	8	8
7. OVERALL COST	6	8	6
8. EXTENT OF USE	2	8	6

Level 2 - Flocculation --> Nonmechanical Menu:

DESCRIBE

BAFFLED: USE THIS OPTION FOR SELECTING BAFFLED UNITS FOR FLOCCULATION. IN THIS OPTION VERTICAL BAFFLE AND HORIZONTAL BAFFLED ARE IMPLEMENTED. BAFFLE PLATES CAN BE OF STEEL, WOOD OR CONCRETE. VELOCITY GRADIENTS ARE PURPOSELY INTENSIFIED BY ENFORCED CHANGES IN THE DIRECTION OF FLOW. IT IS A SIMPLE SYSTEM BUT IS NOT FLEXIBLE AND INVOLVES MUCH LOSS OF HEAD. THE DETENTION PERIOD IS ALSO RESTRICTED AS OTHERWISE LONG CHANNELS ARE REQUIRED. THESE UNITS ARE RECOMMENDED FOR FLOW UP TO 200 CUM/HR.

GRAVITY: CHOOSE THIS OPTION FOR GRAVITY FLOCCULATION UNIT FROM THE OPTIONS STONE MEDIUM AND FLOC MODULE.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	BAFFLED	GRAVITY
1. HYDRAULIC RETENTION TIME, MIN	10 - 20	10 - 35
2. VELOCITY GRADIENT, PER SEC	20 - 75	10 - 100
3. FLOW THROUGH VELOCITY, M/S	0.10 - 0.30	0.05 - 0.45
4. HEAD LOSS, M OF WATER	0.15 - 0.60	0.10 - 1.2

COMPARISON

DESCRIPTION	BAFFLED	GRAVITY
1. EFFICIENCY WITH VARIABLE INFLUENT QUANTITY	4	4
2. EFFECTIVENESS ON SMALL SCALE	B	B
3. EFFECTIVENESS ON BIG WORKS	D	E
4. ADVANTAGEOUS USE OF LAND	E	C
5. FREEDOM FROM MANUFACTURERS PATENTS	A	D
6. SKILLED PERSON REQUIREMENT	6	6
7. OVERALL COST	6	6
8. EXTENT OF USE	6	2

evel 3 - Flocculation --> Nonmechanical --> Baffled Menu:

DESCRIBE

VERTICAL BAFFLED: USE THIS OPTION FOR SELECTING VERTICAL BAFFLED UNIT FOR FLOCCULATION. VELOCITY GRADIENTS ARE PURPOSELY INTENSIFIED BY ENFORCED CHANGES IN THE DIRECTION OF FLOW UPWARDS AND DOWNWARDS ALTERNATIVELY. IN THIS UNIT A HOMOGENEOUS MIXTURE OF THE SUSPENDED PARTICLES IS MAINTAINED DUE TO ALTERNATE RISE AND FALL OF WATER, WHICH PREVENTS DEPOSITION OF SLUDGE. IN AS MUCH AS THE DIRECTION OF FLOW IS THE ONLY SIGNIFICANT DIFFERENCE BETWEEN THESE TWO TYPES, THEIR ADVANTAGES AND DISADVANTAGES ARE VIRTUALLY THE SAME.

evel 1 - Softening Menu:

DESCRIBE

CHEMICAL: USE THIS OPTION FOR DESIGN OF CHEMICAL SOFTENING UNITS. IN THIS OPTION CHEMICAL DOSE IS CALCULATED AND THEREAFTER RAPID MIX, FLOCCULATION AND SEDIMENTATION UNITS ARE DESIGNED. SELECT THIS OPTION IF WATER CONTAINS HARDNESS GREATER THAN 500MG/L OR/AND TURBIDITY COLOR AND IRON SALTS BECAUSE THESE HAVE TENDENCY TO FOUL THE ION EXCHANGE RESINS BY COATING ON THE GRANULES. CHEMICAL SOFTENING CANNOT REDUCE THE HARDNESS OF WATER TO LESS THAN 40MG/L WHILE ION EXCHANGE SOFTENING CAN PRODUCE WATER WITH LESS HARDNESS. THIS CAN BE USED AS PRETREATMENT UNIT FOR WATERS HAVING HIGH HARDNESS TO BE USED FOR INDUSTRIAL USE.

ION EXCHANGE: USE THIS OPTION FOR DESIGN OF ION EXCHANGE SOFTENING UNIT. THIS PROCESS CAN PRODUCE A ZERO HARDNESS WATER. HOWEVER, THE TOTAL DISSOLVED SOLIDS ARE NOT REDUCED. IS GENERALLY USED AS POLISHING UNIT AFTER CHEMICAL TREATMENT.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	CHEMICAL	ION EXCHANGE
1. EFFLUENT CALCIUM HARDNESS AS CALCIUM CARBONATE, MG/L	40 - 100	0 - 10
2. EFFLUENT MAGNESIUM HARDNESS AS CALCIUM CARBONATE, MG/L	10 - 30	0 - 5
3. OPERATING pH	4 - 8	6.5 - 8
4. INFLUENT HARDNESS AS CALCIUM CARBONATE, MG/L	100 - 5000	LESS THAN 500

COMPARISON

	DESCRIPTION	CHEMICAL	ION EXCHANGE
1.	EFFICIENCY WITH TURBID WATERS	10	2
2.	EFFICIENCY WITH LOW pH WATER	2	8
3.	EFFICIENCY WITH WATER CONTAINING IRON AND MANGANESE	8	2
4.	PRODUCTION OF ZERO HARDNESS WATER	2	10
5.	SUITABILITY FOR DOMESTIC WATER SUPPLY	B	C
6.	SUITABILITY FOR INDUSTRIAL WATER SUPPLY	D	A
7.	REMOVAL OF TOTAL DISSOLVED SOLIDS	8	0
8.	EFFICIENCY IN VARIABLE INFLUENT QUANTITY	4	8
9.	SKILLED PERSON REQUIREMENT	4	8
10.	OVERALL COST	4	8
11.	EXTENT OF USE	8	4

.evel 1 - Filtration Menu:

DESCRIBE

SLOW SAND FILTER: USE THIS OPTION FOR DESIGN OF SLOW SAND FILTER UNIT. THIS UNIT CONSISTS OF A WATER TIGHT BASIN CONTAINING A LAYER OF SAND 75 TO 90 CM THICK, SUPPORTED ON A LAYER OF GRAVEL 20 TO 30 CM THICK. THE GRAVEL IS UNDERLAID BY A SYSTEM OF UNDER DRAIN PIPES WHICH LEAD THE WATER TO A SINGLE POINT OF OUTLET WHERE A DEVICE IS LOCATED TO CONTROL THE RATE OF FLOW THROUGH THE FILTER. AFTER SOME INTERVALS THE TOP LAYER OF SAND IS SCRAPED AND EITHER WASHED AND REUSED OR WASTED. TREATMENT IN THIS UNIT REQUIRES MINIMUM SKILL IN OPERATION.

HIGH RATE FILTER: USE THIS OPTION FOR DESIGN OF HIGH RATE FILTER UNITS. WATER SHOULD RECEIVE PRETREATMENT BEFORE PASSING THROUGH THIS UNIT. THE WATER FLOWS DOWN THE FILTERS UNDER GRAVITY. THE FILTRATION MEDIUM CAN BE SINGLE, DUAL OR MULTI UNDERLAID BY

GRAVEL. THE FILTRATION MATERIALS ARE NATURAL SILICA SAND, CRUSHED ANTHRACITE, CRUSHED MAGNETITE AND GARNET SANDS. AFTER SOME TIME THE FILTER IS BACK WASHED AND ENTRAPPED MATERIAL IS WASHED AWAY. THIS UNIT REQUIRES LESS SPACE THAN SLOW SAND FILTER AND IS SUITABLE FOR LARGE PLANTS. HOWEVER, TREATMENT IN THIS UNIT REQUIRES SKILLED SUPERVISION FOR OPERATION.

PRESSURE FILTER: CHOOSE THIS OPTION FOR DESIGN OF PRESSURE FILTERS FROM THE OPTIONS AVAILABLE OF SINGLE, DUAL AND MULTI MEDIA. THESE UNITS ARE BASED ON THE SAME PRINCIPLE AS HIGH RATE GRAVITY FILTERS. HOWEVER, WATER IS PASSED THROUGH A CYLINDRICAL TANK USUALLY MADE OF STEEL OR CAST IRON WHERE THE UNDERDRAIN GRAVEL AND SAND ARE PLACED. THEY ARE COMPACT AND CAN BE PREFABRICATED AND MOVED TO SITE. ECONOMY IS POSSIBLE IN SMALLER PLANTS. PRETREATMENT IS ESSENTIAL. THE TANK AXIS MAY EITHER BE VERTICAL OR HORIZONTAL.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	SLOW SAND	HIGH RATE	PRESSURE
1. DEPTH OF FILTER MEDIA, M	0.8 - 1.0	0.6 - 0.75	1.5 - 1.7
2. FILTRATION RATE, M/HR	0.1 - 0.2	4.8 - 6	7.2 - 18
3. EFFECTIVE SIZE OF FILTER MEDIA, MM	0.2 - 0.3	0.45-0.70	NA
4. UNIFORMITY COEFFICIENT OF FILTER MEDIA	3 - 5	1.3 - 1.7	NA
5. STANDING WATER DEPTH OVER FILTER BED, M	0.5 - 2.0	1 - 3.0	1.0 - 7
4. HEAD LOSS, M OF WATER	0.5 - 1.5	1.0 - 2.5	1.0 - 5

COMPARISON

DESCRIPTION	SLOW SAND	HIGH RATE	PRESSURE
1. EFFICIENCY IN VARIABLE INFLUENT QUALITY	8	6	6
2. EFFECTIVENESS ON SMALL SCALE	A	B	A
3. EFFECTIVENESS ON BIG WORKS	D	A	C
4. ADVANTAGEOUS USE OF LAND	E	C	A
5. FREEDOM FROM MANUFACTURERS PATENTS	B	D	E
6. SKILLED PERSON REQUIREMENT	2	6	8
7. OVERALL COST	4	6	8
8. EXTENT OF USE	8	6	2

›vel 2 - Filtration --> High Rate Menu:

DESCRIBE

SINGLE MEDIA: USE THIS OPTION FOR DESIGN OF SINGLE MEDIA HIGH RATE FILTER UNIT. THE WATER FLOWS DOWN THE FILTERS UNDER GRAVITY. THE FILTRATION MEDIUM USED IS SAND, THE SPECIFICATION OF WHICH ARE PROVIDED IN DESIGN OUTPUT.

DUAL MEDIA: THE FILTRATION MEDIUM CONSISTS OF TWO DIFFERENT MATERIALS. THE FILTRATION MATERIALS AVAILABLE ARE NATURAL SILICA SAND, CRUSHED ANTHRACITE, CRUSHED MAGNETITE AND GARNET SAND. GENERALLY COAL IS USED OVER SAND BED.

MULTI MEDIA: THE FILTRATION MEDIUM CONSISTS OF MORE THAN TWO DIFFERENT MATERIALS. THE FILTRATION MATERIALS AVAILABLE ARE NATURAL SILICA SAND, CRUSHED ANTHRACITE, CRUSHED MAGNETITE AND GARNET SAND. GENERALLY GARNET SAND IS ADDED BELOW COAL SAND BED TO CONSTRUCT MULTIMEDIA FILTRATION. USE OF MULTIMEDIA ASSURES SUPERIOR PERFORMANCE ONLY IF THE MATERIALS USED ARE PROPERLY SIZED.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE
PLEASE REFER TO EITHER DESCRIBE LEVEL OR COMPARE LEVEL OF GUIDELINE OPTION FOR OTHER DETAILS. NO GUIDANCE AVAILABLE AT THIS LEVEL

COMPARISON
PLEASE REFER TO EITHER DESCRIBE LEVEL OR PERFORMANCE LEVEL OF GUIDELINE OPTION FOR OTHER DETAILS. NO GUIDANCE AVAILABLE AT THIS LEVEL

evel 2 - Filtration --> Pressure Menu:

DESCRIBE

SINGLE MEDIA: CHOOSE THIS OPTION FOR DESIGN OF SINGLE MEDIA PRESSURE FILTER.

DUAL MEDIA: CHOOSE THIS OPTION FOR DESIGN OF DUAL MEDIA PRESSURE FILTER.

MULTI MEDIA: CHOOSE THIS OPTION FOR DESIGN OF MULTI MEDIA PRESSURE

FILTER.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
COMPARE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

COMPARISON

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
PERFORMANCE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

Level 1 - Disinfection Menu:

DESCRIBE

PREDISINFECTION: USE THIS OPTION FOR DESIGN OF CHLORINATION, OZONATION AND ULTRAVIOLET DISINFECTION UNITS JUST AFTER PRESETTLING. THE POINT OF APPLICATION AS WELL AS THE DOSAGE OF DISINFECTANT IS CONTROLLED BY THE OBJECTIVES i.e. CONTROL OF BIOLOGICAL GROWTHS IN RAW WATER CONDUITS, PROMOTION OF IMPROVED

COAGULATION, PREVENTION OF MUD BALLS AND SLIME FORMATION IN FILTERS, REDUCTION OF TASTES, ODOR AND COLOR AND MINIMIZING THE POST DISINFECTION DOSE WHEN DEALING WITH HEAVILY POLLUTED WATERS.

POST DISINFECTION: USE THIS OPTION FOR DESIGN OF CHLORINATION, OZONATION AND ULTRAVIOLET DISINFECTION UNITS AFTER ANY UNIT TREATMENT PROCESS AND PRIOR TO DISTRIBUTION TO CONSUMER. IT IS CARRIED OUT TO INACTIVATE OR CONTROL THE MICROORGANISMS AND PATHOGENS IN WATER WHICH CAN ADVERSELY AFFECT ITS QUALITY OR LEAD TO DISEASE FROM MICROBIAL ACTIVITY.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
COMPARE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

COMPARISON

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
PERFORMANCE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

vel 2 - Disinfection --> Pre Menu:

DESCRIBE

CHLORINATION: USE THIS OPTION FOR DESIGN OF PRE-CHLORINATION UNIT JUST AFTER PRESETTLING. IT CONTROLS BIOLOGICAL GROWTHS IN RAW WATER CONDUITS, PROMOTES COAGULATION, PREVENTS MUD BALLS AND SLIME FORMATION IN FILTERS, REDUCES TASTES, ODOR AND COLOR.

ULTRAVIOLET RADIATION: IT IS EFFECTIVE IN INACTIVATING ALL TYPES OF BACTERIA AND VIRUSES. THE ADVANTAGES ARE READY AUTOMATION, NO CHEMICAL HANDLING, SHORT RETENTION TIME, NO EFFECT UPON CHEMICAL CHARACTERISTICS AND TASTE, LOW MAINTENANCE, NO ILL EFFECT FROM OVER DOSAGES. THE DISADVANTAGES ARE LACK OF RESIDUAL PROTECTION, RELATIVELY HIGH COST, AND NEED FOR LOW TURBIDITY IN THE WATER TO INSURE PENETRATION OF RAYS. THE WATER BEING TREATED IS MADE TO FLOW IN A THIN FILM PAST A SERIES OF QUARTZ MERCURY VAPOR ARC LAMPS EMITTING U.V. LIGHT. THIS PROCESS IS USED PRIMARILY IN INDUSTRIAL APPLICATIONS AND PRIVATE INSTALLATIONS.

OZONATION: IT IS EFFECTIVE BOTH IN DISINFECTION AND REDUCTION OF TASTES AND ODORS. IT IS ALSO EFFECTIVE AS A GERMICIDE, IN DESTRUCTION OF ORGANIC MATTERS WHICH MIGHT PRODUCE TASTES OR ODORS, AND IN OXIDATION OF IRON AND MANGANESE. THE DISADVANTAGES

WHICH HAVE RESTRICTED ITS USE ARE ITS HIGH COST RELATIVE TO CHLORINATION, THE NEED TO GENERATE OZONE AT THE POINT OF USE, AND ITS SPONTANEOUS DECAY WHICH PREVENTS MAINTENANCE OF RESIDUAL IN THE DISTRIBUTION SYSTEM.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	CHLORINATION	ULTRA VIOLET	OZONATION
1. CONTACT TIME, MIN	10 - 30	-	1.0 - 2.5
2. PERCENTAGE OF KILL ACHIEVED	99%	99.99%	99.99%

COMPARISON

DESCRIPTION	CHLORINATION	ULTRA VIOLET	OZONATION
1. EFFICIENCY IN VARIABLE INFLUENT QUANTITY	4	6	4
2. EFFECTIVENESS IN VARIABLE pH	E	A	C
3. RESIDUAL DISINFECTANT	8	2	2
4. ODOR ADDITION PROBLEM	10	2	2
5. EFFECTIVENESS IN TURBID WATER	C	E	E
2. EFFECTIVENESS ON SMALL SCALE	B	B	B
3. EFFECTIVENESS ON BIG WORKS	B	E	E
4. ADVANTAGEOUS USE OF LAND	B	A	A
5. FREEDOM FROM MANUFACTURERS PATENTS	B	E	E
6. SKILLED PERSON REQUIREMENT	6	8	8
7. OVERALL COST	4	8	8
8. EXTENT OF USE	10	2	4

evel 2 - Disinfection --> Post Menu:

DESCRIBE

CHLORINATION: USE THIS OPTION FOR DESIGN OF POST-CHLORINATION UNITS AFTER ANY UNIT TREATMENT PROCESS. THE AVAILABLE OPTIONS ARE BREAK POINT CHLORINATION, SUPER CHLORINATION AND PLAIN CHLORINATION. IT IS USED FOR DISINFECTION, PREVENTION AND DESTRUCTION OF ODORS, IRON REMOVAL AND COLOR REMOVAL. IT GENERALLY FOLLOWS FILTRATION UNIT BUT WHEN APPLIED AHEAD OF FILTERS AND SUBSEQUENT TO PRECHLORINATION, POST CHLORINATION AIDS IN MAINTAINING FILTER EFFICIENCY.

ULTRAVIOLET RADIATION: IT IS EFFECTIVE IN INACTIVATING ALL TYPES OF BACTERIA AND VIRUSES. THE ADVANTAGES ARE READY AUTOMATION, NO CHEMICAL HANDLING, SHORT RETENTION TIME, NO EFFECT UPON CHEMICAL CHARACTERISTICS AND TASTE, LOW MAINTENANCE, NO ILL EFFECT FROM OVER DOSAGES. THE DISADVANTAGES ARE LACK OF RESIDUAL PROTECTION, RELATIVELY HIGH COST AND NEED FOR LOW TURBIDITY IN THE WATER TO INSURE PENETRATION OF RAYS. THE WATER BEING TREATED IS MADE TO FLOW IN A THIN FILM PAST A SERIES OF QUARTZ MERCURY VAPOR ARC LAMPS EMITTING U.V. LIGHT. THIS PROCESS IS USED PRIMARILY IN INDUSTRIAL APPLICATIONS AND PRIVATE INSTALLATIONS.

OZONATION: IT IS EFFECTIVE BOTH IN DISINFECTION AND REDUCTION OF TASTES AND ODORS. IT IS ALSO EFFECTIVE AS A GERMICIDE, IN DESTRUCTION OF ORGANIC MATTERS WHICH MIGHT PRODUCE TASTES OR ODORS, AND IN OXIDATION OF IRON AND MANGANESE. THE DISADVANTAGES WHICH HAVE RESTRICTED ITS USE ARE ITS HIGH COST RELATIVE TO CHLORINATION, THE NEED TO GENERATE OZONE AT THE POINT OF USE, AND ITS SPONTANEOUS DECAY WHICH PREVENTS MAINTENANCE OF RESIDUAL IN THE DISTRIBUTION SYSTEM.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	CHLORINATION	ULTRA VIOLET	OZONATION
1. CONTACT TIME, MIN	10 - 30	-	1.0 - 2.5
2. PERCENTAGE OF KILL ACHIEVED	99%	99.99%	99.99%

COMPARISON

DESCRIPTION	CHLORINATION	ULTRA VIOLET	OZONATION
1. EFFICIENCY IN VARIABLE INFLUENT QUANTITY	4	6	4
2. EFFICIENCY IN VARIABLE pH	2	10	6
3. RESIDUAL DISINFECTANT	8	2	2
4. ODOR ADDITION PROBLEM	10	2	2
5. EFFECTIVENESS IN TURBID WATER	C	E	E
2. EFFECTIVENESS ON SMALL SCALE	B	B	B
3. EFFECTIVENESS ON BIG WORKS	B	E	E
4. ADVANTAGEOUS USE OF LAND	B	A	A
5. FREEDOM FROM MANUFACTURERS PATENTS	B	E	E
6. SKILLED PERSON REQUIREMENT	6	8	8
7. OVERALL COST	4	8	8
8. EXTENT OF USE	10	2	4

evel 1 - Advance Processes Menu:

DESCRIBE

ION EXCHANGE: USE THIS OPTION FOR DESIGN OF ION EXCHANGE UNIT. IN THIS UNIT A SALT SOLUTION IS PERCOLATED THROUGH A CATION EXCHANGE RESIN TREATED WITH ACIDS. THE EFFLUENT CONTAINS EQUIVALENT AMOUNTS OF CORRESPONDING ACIDS. WHEN THIS ACIDIC EFFLUENT IS PASSED

THROUGH AN ANION EXCHANGE RESIN WHICH HAS BEEN TREATED WITH ALKALI SO THAT IT CONTAINS REPLACEABLE HYDROXYL IONS. THE ANIONS ARE EXCHANGED FOR THE HYDROXYL IONS WITH THE RESULT THAT THE EFFLUENT IS RENDERED FREE FROM SALTS. IT IS POSSIBLE BY THIS UNIT TO REMOVE SALTS FROM SALINE/BRACKISH WATER BY USE OF PERCOLATION COLUMNS. THE BEDS CAN BE REGENERATED AND USED REPEATEDLY WITHOUT APPRECIABLE LOSS IN CAPACITY.

DESALINATION: CHOOSE THIS OPTION FOR SELECTING REVERSE OSMOSIS OR/AND ELECTRO DIALYSIS FOR REMOVING SALTS FROM WATER. THESE PROCESSES USE SEMIPERMEABLE MEMBRANES TO SEPARATE THE SOLUTE FROM SOLVENT. THESE MEMBRANES MAY BE NATURAL OR SYNTHETIC.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
COMPARE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

COMPARISON

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
PERFORMANCE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

vel 2 - Advance Processes --> Desalination Menu:

DESCRIBE

REVERSE OSMOSIS: USE THIS OPTION FOR DESIGN OF REVERSE OSMOSIS UNIT. IT IS A MEMBRANE PERMEATION PROCESS FOR OBTAINING SALT FREE WATER FROM SALINE/BRACKISH WATER. THE INFLUENT RAW WATER IS PASSED OVER THE SURFACE OF SEMI PERMEABLE MEMBRANE AT A PRESSURE IN EXCESS OF THE EFFECTIVE OSMOTIC PRESSURE OF THE INFLUENT WATER. THE PERMEATING LIQUID IS COLLECTED AS THE PRODUCT AND CONCENTRATED INFLUENT SOLUTION IS GENERALLY DISCARDED. THE MEMBRANE USED IS HIGHLY PERMEABLE TO WATER BUT HIGHLY IMPERMEABLE TO THE SOLUTES AND CAPABLE OF WITHSTANDING THE APPLIED PRESSURE WITHOUT FAILURE. BECAUSE OF ITS SIMPLICITY IN EXECUTION, REVERSE OSMOSIS HAS CONSIDERABLE POTENTIAL FOR WATER TREATMENT.

ELECTRO DIALYSIS: USE THIS OPTION FOR DESIGN OF ELECTRO DIALYSIS UNIT. IT IS ALSO A MEMBRANE PERMEATION PROCESS AIDED BY THE ELECTROMOTIVE FORCE. A NUMBER OF ELECTROLYTIC CELLS ARE USED IN SERIES. THE CELLS ARE COMPOSED OF 3 COMPARTMENTS SEPARATED FROM EACH OTHER BY SUITABLE MEMBRANES. THE SALINE WATER CIRCULATES IN SERIES THROUGH MIDDLE COMPARTMENTS OF CELLS AND UNDERGOES PURIFICATION. A DIRECT CURRENT OF 110-220 VOLTS IS EMPLOYED. THE ELECTRODES ARE CONTINUOUSLY WASTED WITH TREATED WATER. HOWEVER, THE MEMBRANES GET BADLY DAMAGED DUE TO CORROSION AND SCALE FORMATION. THIS PROCESS IS ADOPTED FOR WATERS CONTAINING LESS THAN 10 000 MG/L OF DISSOLVED SOLIDS.

GUIDELINES: SELECT THIS OPTION FOR VIEWING GUIDELINES FOR SELECTION OF ABOVE OPTIONS.

ESCAPE: SELECT THIS OPTION TO GO BACK TO PREVIOUS LEVEL (MENU).

PERFORMANCE

DESCRIPTION	REVERSE OSMOSIS	ELECTRODIALYSIS
1. RECURRING COST OF DESALINATION, Rs/CUM	9 - 31	8 - 24
2. OVERALL COST, Rs/CUM	40 - 131	28 - 85
3. RATIO OF ENERGY COST TO TOTAL OPERATING COST	40 - 60 %	N.A.
4. ENERGY REQUIREMENT KWH/ CUM	12 - 18	N.A.
5. MEMBRANE LIFE, YEARS	3	5

COMPARISON

PLEASE REFER TO EITHER
DESCRIBE LEVEL
OR
PERFORMANCE LEVEL
OF GUIDELINE OPTION FOR OTHER
DETAILS.
NO GUIDANCE AVAILABLE
AT THIS LEVEL

APPENDIX II - UNIT DESIGN METHODOLOGY

Diffused Air Process:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Nozzle Specifications (Diameter and Spacing); Pipe Specifications (Diameter and Spacing); Dissolved Oxygen Concentration in Influent and Effluent, DO_i and DO_e; Tank Length to Height and Tank Width to Height Ratios.

2. Compute Tank Parameters: Hydraulic Retention Time; Volume; Length; Width; Height. Use Equation Block 001*.

3. Compute Diffuser Parameters: Number of Pipes; Pipe Spacing; Number of Nozzles per Pipe; Nozzle Spacing on Pipe; Total Number of Nozzles. Use Equation Block 002.

4. Compute Compressor Parameters: Airflow; Air Delivery Pressure and Brake Horse Power. Use Equation Block 003.

5. Display: Flow Rate; Tank Parameters; Diffuser Parameters; Compressor Parameters.

DEFAULT PARAMETER VALUES

T = 25^{o}C; Diameter of Nozzle = 10 mm; Spacing of Nozzle = 1.0 m; Diameter of Pipe = 0.1 m; Spacing of Pipe = 1.0 m; DO_e = 5.5 mg l^{-1}; Tank Length to Height Ratio = 3; Tank Width to Height Ratio = 1.

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* For conveniance all Equation Blocks are given in sequence at the end of this Appendix.

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Cascade Weir Length, L_{cw}; Dissolved Oxygen Concentration in Influent and Effluent, DO_i and DO_e; Drop Height.

2. Compute: Saturated Dissolved Oxygen Concentration, DO_s; Critical Height over Upstream Weir, H_{crit}; Upstream and Downstream Water Level Difference, H_{diff}; Weir Loading, q. Use Equation Block 004.

3. Put Number of Cascades, n = 1

4. Compute: Critical Dissolved Oxygen Deficit Ratio(r) at 20^oC, r_{20}; r at T^oC, r_T; Dissolved Oxygen Concentration at Downstream of n^{th} Weir Step, DO_e. Use Equation Block 005

5. If DO_e < Specified DO_e then goto 6 else to 7

6. Put n = n + 1; $DO_i = DO_e$ and goto 4

7. If $DO_e > DO_s$ then Put $DO_e = DO_s$; Put Number of Cascades, $N_{cas} = n$;

8. Compute Cascade Parameters: Height of Cascade Wall at Upstream; Height of Cascade Wall at Downstream; Length of Nappe; Thickness of Cascade Wall; Length of Cascade Unit; Width of Cascade Unit; Head Loss over One Cascade Weir; Total Head Loss in Cascade Unit. Use Equation Block 006.

9. Display: Flow Rate; Temperature; Dissolved Oxygen Concentrations; Cascade Parameters.

DEFAULT PARAMETER VALUES

$T = 25^oC$; $L_{cw} = 2$ m; Drop Height = 0.20 m; $DO_e = 5.5$ mg l^{-1}.

Spray Aeration Process:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Cascade Weir Length, L_{cw}; Dissolved Oxygen Concentration in Influent and Effluent, DO_i and DO_e; Wind Velocity; Nozzle Specifications (Diameter, Spacing and Number of Nozzles per Pipe); Minimum Spacing of Pipe; Depth of Tank.

2. Compute: Number of Pipes; Minimum Spacing of Pipe; Total Number of Nozzle; Use Equation Block 007.

3. If Computed Minimum Spacing of Pipe < Specified Minimum Spacing of Pipe then Put Minimum Spacing of Pipe = Specified Minimum Spacing of Pipe.

4. Compute: Tank Parameters (Length and Width). Use Equation Block 008.

5. Display: Flow Rate; Temperature; Dissolved Oxygen Concentrations; Nozzle Parameters; Pipe Parameters; Tank Parameters; Wind Velocity.

DEFAULT PARAMETER VALUES

T = 25°C; Wind Velocity = 5.5 m s^{-1}; DO_e = 5.5 mg l^{-1}; Nozzle Specifications (Diameter = 10 mm, Spacing = 1.0 m, Number of Nozzles per Pipe = 15); Minimum Spacing of Pipe = 1.0 m; Depth of Tank = 1.0 m.

Tube Settlers:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Settling Velocity, v_s; Flow Velocity through Tube, v; Width of Tank, W_{tank}; Type of Tube Settler; Shape of Tube; Thickness of Tube; Inclination from Horizontal, θ.

2. If Shape of Tube = Square then goto 2A else to 2B
   2A. Put Shape Factor, S_c = 11/8; Input Side of Tube, d and goto 3.
   2B. Consider Shape of Tube = Circular, Put Shape Factor, S_c = 4/3; Input Diameter of Tube, d.

3. Compute: Relative Length of Tube, L; Transition Relative Length, L'; Tube Parameters (Length, Total Number, Number in One Row and Number in One Column); Tank Parameters (Length, Width and Height). Use Equation Block 009.

4. Display: Flow Rate; Tank Parameters; Tube Parameters; Settling Velocity; θ.

DEFAULT PARAMETER VALUES

T = 25^{o}C; v_s = 0.0008 m s^{-1}; v = 0.005 m s^{-1}; W_{tank} = 3.0 m; Type of Tube Settler = Steeply Inclined; Shape of Tube = Square; d = 0.05 m; Thickness of Tubes = 0.005 m; θ = 10^{o} for Essentially Horizontal; θ = 60^{o} for Steeply Inclined.

Parallel Plate Settler:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Settling Velocity, v_s; Flow Velocity through Plates, v; Width of Tank, W_{tank}; Type of Plate Settler; Spacing between Plates, d; Plate Thickness; Inclination from Horizontal, θ.

2. Put Shape Factor $S_c = 1$

3. Compute: Relative Length of Plate, L; Transition Relative Length, L'; Plate Parameters (Length and Total Number); Tank Parameters (Length, Width and Height). Use Equation Block 010.

4. Display: Flow Rate; Tank Parameters; Plate Parameters; Settling Velocity; θ.

DEFAULT PARAMETER VALUES

T = 25 ^oC; V_s = 0.0008 m s^{-1}; Flow Velocity through Plates = 0.005 m s^{-1}; W_{tank} = 3.0 m; Type of Plate Settler = Steeply Inclined; Spacing between Plates = 0.05 m; Plate Thickness = 0.005 m; θ = 10^o for Essentially Horizontal; θ = 60^o for Steeply Inclined.

Rectangular Settling Tank:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Location of Settling Tank; Maximum Weir Loading; Velocity in Ports; Bed Slope.

2. If Location of Settling = Settling Before Coagulation-Flocculation then goto 3, else to 4

3. Input: Size of Particle to be removed, d_s; Height of Tank; Ratio of Length to Width of Tank, R_{lw}; Ratio of Width of Tank to Height of Tank, R_{wh}; goto 5.

4. Input: Surface Overflow Rate; Height of Tank; Ratio of Length to Width of Tank, R_{lw}; Ratio of Width of Tank to Height of Tank, R_{wh}; goto 6.

5. Compute: Settling Velocity of Particle; Put Surface Overflow Rate = Settling Velocity of Particle. Use Equation Block 011.

6. Put Number of Tank = 1; Number of Lateral Effluent Launders = 0.

7. Compute: Flow Rate in Each Tank; Width of Tank; Length of Tank. Use Equation Block 012.

8. If R_{lw} < Length of Tank/ Width of Tank then Put R_{wh} = 1.1 R_{wh} goto 7; If Length of Tank < 3 then Put Length of Tank = 3; If Width of Tank < 1 then Put Width of Tank = 1.

9. Compute: Length of Outlet Zone; Width of Lateral Effluent Launders; Weir Loading. Use Equation Block 013.

continued on page 86

continued from page 85

10. If Weir Loading ≥ Specified Maximum Weir Loading then Put Number of Lateral Effluent Launders = Number of Lateral Effluent Launders + 1, goto 9.

11. Compute: Inlet Parameters (Number of Ports and Diameter of Ports); Lateral Effluent Launder Parameters (Width and Depth); Influent Launder Parameters (Width and Depth); Total Length of Tank; Use Equation Block 014.

12. Display: Temperature; Location of Settling Tank; Surface Overflow Rate; Influent Launder Parameters; Baffle Wall Parameters; Main and Lateral Effluent Launder Parameters Tank Parameters; Bed Slope.

DEFAULT PARAMETER VALUES

T = 25^{o}C; Location of Settling Tank = Settling Before Coagulation- Flocculation; Maximum Weir Loading = 0.002m s^{-1}; Velocity in Ports = 0.30 m s^{-1}; Spacing of Ports = 0.5 m; d_s= 10 μ m; R_{lw} = 3; R_{wh} = 1; Height of Tank = 3 m (For Settling Before Coagulation-Flocculation); Height of Tank = 4.5 m (For Settling After Coagulation-Flocculation); Bed Slope = 10 %. Surface Overflow Rate = 0.00023 m s^{-1} (For Settling After Coagulation-Flocculation).

Radial Flow Circular Clarifier:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Surface Overflow Rate; Maximum Weir Loading; Velocity in Ports; Spacing of Ports; Bed Slope and Height of Tank.

2. Put Number of Tank = 1.

3. Compute: Flow Rate in Each Tank; Diameter of Tank; Diameter of Baffle Wall; Number of Ports; Diameter of Ports; Revised Diameter of Tank; Weir Loading; Width of Effluent Launder; Depth of Effluent Launder; Diameter of Influent Pipe. Use Equation Block 015.

4. If Weir Loading ≥ Specified Maximum Weir Loading then Put Number of Tank = Number of Tank + 1 and goto 3, else continue

   If Diameter of Tank ≥ 60m then Put Number of Tank = Number of Tank + 1 and goto 3, else to 5.

5. Display: Flow Rate; Number of Tank; Tank Parameters; Effluent Launder Parameters; Diameter of Influent Pipe; Bed Slope.

DEFAULT PARAMETER VALUES

Surface Overflow Rate = 0.00064 m s^{-1}; Maximum Weir Loading = 0.0018 m s^{-1}; Velocity in Ports = 0.30 m s^{-1}; Spacing of Ports = 0.15 m; Height of Tank = 4.5 m; Bed Slope = 10 %.

Circumferential Flow Circular Clarifier:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Surface Overflow Rate; Maximum Weir lce StudyLoading; Velocity in Ports; Bed Slope and Height of Tank.

2. Put Number of Tank = 1;

3. Compute: Flow Rate in Each Tank; Diameter of Tank; Height of Port Opening; Effluent Launder Parameters (Width and Depth); Diameter of Influent Pipe; Weir Loading. Use Equation Block 016.

4. If Weir Loading > Specified Maximum Weir Loading then Put Number of Tank = Number of Tank + 1, goto 3;
   If Diameter of Tank > 60 m then Put Number of Tank = Number of Tank + 1, goto 3;

5. Display: Flow Rate; Number of Tank; Tank Parameters; Effluent Launder Parameters; Height of Port Opening; Diameter of Influent Pipe; Bed Slope.

DEFAULT PARAMETER VALUES

Surface Overflow Rate = 0.00064 m s^{-1}; Maximum Weir Loading = 0.0018 m s^{-1}; Velocity in Ports = 0.3 m s^{-1}; Height of Tank = 4.5 m; Bed Slope = 10 %.

Inline Blender (Rapid Mix):

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Velocity Gradient, G; Power Input per Unit Flow Rate; Ratio of Length to Depth of Tank, R_{lh}; Ratio of Length to Width of Blade, R_{bl}; Efficiency of Motor and Drive, η.

2. Compute: Tank Parameters (Length, Width and Height); Blade Parameters (Length, Height and Number of Blades); Revolutions per Min of Shaft; Motor Power. Use Equation Block 017.

3. Display: Flow Rate; Temperature; Velocity Gradient; Tank Parameters; Blade Parameters; Revolutions per Min of Shaft; Motor Power.

DEFAULT PARAMETER VALUES

T = 25^{o}C; Velocity Gradient = 5000 s^{-1}; Power Input per Unit Flow Rate = 0.001 watt $m^{-3}s^{-1}$; R_{lh} = 2; R_{blw} = 6; η = 80 %.

Turbine Type Rapid Mix:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Hydraulic Retention Time; Velocity Gradient, G; Efficiency of Motor and Drive, η; Ratio of Diameter to Depth of Tank, R_{dd}; Ratio of Length to Width of Blade, R_{blw}.

2. Compute: Tank Parameters (Volume, Diameter and Depth); Blade Parameters (Length, Width and Number of Blades);

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Revolutions per Min of Shaft; Motor Power. Use Equation Block 018.

3. Display: Flow Rate; Temperature; Hydraulic Retention Time; Velocity Gradient; Tank Parameters; Blade Parameters; Revolutions per Min of Shaft; Motor Power.

DEFAULT PARAMETER VALUES

$T = 25^oC$; Hydraulic Retention Time = 77 s; Velocity Gradient = 700 s^{-1}; $R_{dd} = 1$; $R_{blw} = 8$; $\eta = 80\%$.

Vertical Baffled Rapid Mix:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Hydraulic Retention Time; Ratio of Length to Width of Tank, R_{lw}; Ratio of Width to Height of Tank, R_{wh}.

2. Compute: Tank Parameters (Length, Width and Height); Channel Width. Use Equation Block 019.

3. Compute: Channel Parameters (Length and Number); Length of Baffle; Velocity in Channels; Velocity in Slots. Use Equation Block 020.

4. If Velocity in Slots < 1.5 m s^{-1} then Put Width of Channel = Width of Channel/1.1 and goto 3 else continue.

5. Compute: Head Loss in Tank; Water Head Over Outlet Baffle; Velocity Gradient. Use Equation Block 021.

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6. Display: Flow Rate; Tank Parameters; Baffle Parameters; Channel Parameters; Head Loss in Tank; Water Head Over Outlet Baffle; Velocity Gradient.

DEFAULT PARAMETER VALUES

Hydraulic Retention Time = 20 s; Velocity Gradient = 700 s^{-1}; R_{lw} = 5; R_{wh} = 1.

Horizontal Baffled Rapid Mix:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Hydraulic Retention Time; Ratio of Length to Width of Tank, R_{lh}; Ratio of Width to Height of Tank, R_{wh}.

2. Compute: Tank Parameters (Length, Width and Height); Channel Width. Use Equation Block 022.

3. Compute: Channel Parameters (Length and Number); Length of Baffle; Velocity in Channels; Velocity in Slots. Use Equation Block 023.

4. If Velocity in Slots < 1.5 m s^{-1} then Put Width of Channel = Width of Channel/1.1 and goto 3 else continue.

5. Compute: Head Loss in Tank; Water Head Over Outlet Weir; Velocity Gradient. Use Equation Block 024.

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6. Display: Flow Rate; Tank Parameters; Baffle Parameters; Channel Parameters; Head Loss in Tank; Water Head Over Outlet Weir; Velocity Gradient.

DEFAULT PARAMETER VALUES

Hydraulic Retention Time = 20 s; Velocity Gradient = 700 s^{-1}; R_{lw} = 5; R_{wh} = 1.

Inline Blender Flocculator:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Velocity Gradient, G; Hydraulic Retention Time; Ratio of Length to Depth of Tank, R_{lh}; Ratio of Length to Width of Blade, R_{blw}; Efficiency of Motor and Drive, η.

2. Compute: Tank Parameters (Volume, Height, Length and Width); Blade Parameters (Length, Height and Number of Blades); Revolutions per Min of Shaft; Motor Power. Use Equation Block 025.

3. Display: Flow Rate; Temperature; Velocity Gradient; Tank Parameters; Blade Parameters; Revolutions per Min of Shaft; Motor Power.

DEFAULT PARAMETER VALUES

T = 25^{o}C; G = 50 s^{-1}; Hydraulic Retention Time = 1000 s; R_{lh} = 0.5; R_{blw} = 6; η = 80 %.

Paddle Flocculator:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Velocity Gradient, G; Hydraulic Retention Time; Number of Paddles per Shaft; Ratio of Length to Width of Tank, R_{lw}; Ratio of Width to Depth of Tank, R_{wd}; Efficiency of Motor and Drive, η.

2. Put Revolutions per second, $N_s = 0.0333\ s^{-1}$; Tip Velocity $= 0.45\ m\ s^{-1}$; Length of Shaft = 3.0 m; Spacing of Paddles = 0.10 m.

3. Compute: Tank Parameters (Volume, Height, Length and Width). Use Equation Block 026.

4. Compute: Diameter of Outermost Paddles. Use Equation Block 027.

5. If Diameter of Outermost Paddles > 0.8 . Height of Tank
   then put $N_s = 1.1\ N_s$ and goto 4 else continue.

6. Compute: Input Power;
   If Length of Shaft ≤ Length of Tank
   then
   Put Length of Shaft = 0.5 Length of Tank and goto 7
   else continue;
   If Length of Shaft > Length of Tank
   then Put Length of Shaft = 0.9 Length of Tank

7. Compute Number of Shafts;
   If Number of Shafts . Length of Shaft > Length of Tank
   then goto 6 else continue;

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8. Compute: Paddle Parameters (Area, Length and Width); Revolutions per Min of Shaft; Motor Power. Use Equation Block 028.

7. Display: Flow Rate; Temperature; Velocity Gradient; Tank Parameters; Paddle Parameters; Shaft Parameters; Revolutions per Min of Shaft; Motor Power.

DEFAULT PARAMETER VALUES

$T = 25^{o}C$; Velocity Gradient = 50 s^{-1}; Hydraulic Retention Time = 1000 s; R_{lh} = 3; R_{wd} = 6; η = 80 %; Number of Paddles per Shaft = 3.

Flat Blade Turbine Flocculator:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Hydraulic Retention Time; Velocity Gradient, G; Efficiency of Motor and Drive, η; Ratio of Diameter to Depth of Tank, R_{dd}.

2. Put Number of Blades = 2; Maximum Revolutions per Sec of Shaft = 0.25 s^{-1}.

3. Compute: Tank Parameters (Volume, Diameter and Depth); Blade Parameters (Length, Width and Number of Blades). Use Equation Block 029.

4. Compute: Revolutions per Sec of Shaft; Motor Power. Use Equation Block 030.

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5. If Computed Revolutions per Sec of Shaft > Specified Revolutions per Sec of Shaft then Put Power Input = Power Input/1.1 and goto 3 else continue.

6. Display: Flow Rate; Temperature; Hydraulic Retention Time; Velocity Gradient; Tank Parameters; Blade Parameters; Revolutions per Min of Shaft; Power Input; Motor Power.

DEFAULT PARAMETER VALUES

T = 25°C; Hydraulic Retention Time = 1500 s; Velocity Gradient = 50 s^{-1}; R_{dd} = 1; η = 80 %.

Vertical Baffled Flocculator:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Hydraulic Retention Time, t; Ratio of Length to Width of Tank, R_{lw}; Ratio of Width to Height of Tank, R_{wh}; Coagulant.

2. Put Velocity in Channel, v = 0.3 m s^{-1}.

3. Compute: Tank Parameters (Length, Width and Height). Use Equation Block 031.

4. Compute: Channel Parameters (Width, Number and Length);. Length of Baffle; Velocity in Channels; Velocity in Slots; Head Loss in Channels; Velocity Gradient, G. Use Equation Block 032.

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5. If Coagulant = Alum then goto 5A else to 5B

    5A If $Gt < 2.10^4$ then goto 5A1 else to 5A2

    5A1 v = v + 0.01, goto 6

    5A2 If $Gt > 6.10^4$ then goto 5A3 else to 7

    5A3 v = v - 0.01, goto 6

    5B If $Gt < 1.10^5$ then goto 5B1 else to

    5B1 v = v + 0.01, goto 6

    5B2 If $Gt > 1.5.10^5$ then goto 5B3 else to 7

    5B3 v = v - 0.01, goto 6

6. If $0.15 \leq v \leq 0.45$ then goto 4 else Put t = t + 1 and goto 3

7. Compute: Head Loss in Tank; Water Head Over Outlet Baffle. Use Equation Block 033.

8. Display: Flow Rate; Coagulant; Tank Parameters; Baffle Parameters; Channel Parameters; Head Loss in Tank; Water Head Over Outlet Baffle; Velocity Gradient; Length of Baffle; Length of Slot.

DEFAULT PARAMETER VALUES

T = 25°C; Hydraulic Retention Time = 1000 s; R_{lw} = 5; R_{wh} = 1; Coagulant = Alum.

Horizontal Baffled Flocculator:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Hydraulic Retention Time, t; Ratio of Length to Width of Tank, R_{lw}; Ratio of Width to Height of Tank, R_{wh}; Coagulant.

2. Put Velocity in Channel, $v = 0.3\ m\ s^{-1}$.

3. Compute: Tank Parameters (Length, Width and Height). Use Equation Block 034.

4. Compute: Channel Parameters (Width, Number and Length); Length of Baffle; Velocity in Channels; Velocity in Slots; Head Loss in Channels; Velocity Gradient, G. Use Equation Block 035.

5. If Coagulant = Alum then goto 5A else to 5B

   5A If $Gt < 2.10^4$ then goto 5A1 else to 5A2

   5A1 $v = v + 0.01$, goto 6

   5A2 If $Gt > 6.10^4$ then goto 5A3 else to 7

   5A3 $v = v - 0.01$, goto 6

   5B If $Gt < 1.10^5$ then goto 5B1 else to

   5B1 $v = v + 0.01$, goto 6

   5B2 If $Gt > 1.5.10^5$ then goto 5B3 else to 7

   5B3 $v = v - 0.01$, goto 6

6. If $0.15 \leq v \leq 0.45$ then goto 4 else Put $t = t + 1$ and goto 3

7. Compute: Head Loss in Tank; Water Head Over Outlet Wier. Use Equation Block 036.

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8. Display: Flow Rate; Coagulant; Tank Parameters; Baffle Parameters; Channel Parameters; Head Loss in Tank; Water Head Over Outlet Wier; Velocity Gradient; Length of Baffle; Length of Slot.

DEFAULT PARAMETER VALUES

$T = 25^{o}C$; Hydraulic Retention Time = 1000 s; $R_{lw} = 5$; $R_{wh} = 1$; Coagulant = Alum.

Chemical Softening:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Influent Water Parameters (Alkalinity, A_1; Calcium Hardness, H_1; Magnesium Hardness, H_2; Carbon Dioxide, C); Effluent Hardness, H_e.

2. If $H_e \geq H_1 + H_2$ then goto 11 else continue.

3. Compute: Fraction of Water to be treated, X. Use Equation Block 037.

4. If $1 > X > 0.01$ then Put Type of Treatment = Split Treatment and goto 5 else continue.
   If $X \geq 0.01$ then Put Type of Treatment = Complete Treatment else No Treatment Required

5. Compute: Lime Dose, L_1; Soda Dose, S_1; Additional Lime Dose for Mixed Flow, L_2; Additional Soda Dose for Mixed Flow, S_2; Total Lime Dose, Total Soda Dose, Daily Lime Requirement; Daily Soda Requirement; Use Equation Block 038.

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6. If Rapid Mix Design Required then Design Rapid Mix Unit else continue.

7. If Flocculation Unit Design Required then Design Flocculation Unit else continue.

8. If Settling Unit Design Required then Design Settling Unit else continue.

9. If Type of Treatment = Split Treatment then Design Rapid Mix Unit and Settling Unit else continue.

10. Display: Flow Rate; Influent Water Parameters; Effluent Water Parameters; L_1; L_2; S_1; S_2; Total Lime Dose; Total Soda Dose; Daily Lime Requirement; Daily Soda Requirement; Design details of Rapid Mix, Flocculation and Settling Units.

<u>DEFAULT PARAMETER VALUES</u>

A_1 = 300 mg l^{-1} as $CaCO_3$; H_1 = 150 mg l^{-1} as $CaCO_3$; H_2 = 100 mg l^{-1} as $CaCO_3$; C_1 = 100 mg l^{-1} as $CaCO_3$; H_e = 100 mg l^{-1} as $CaCO_3$.

Ion Exchange Softening:

<u>DESIGN LOGISTICS</u>

1. Input: Flow Rate, Q; Temperature, T; Total Influent Hardness; Service Flow Rate; Rinse Water Flow Loading; Regeneration Interval; Free Board; Ratio of Length to Width for Brine Tank, R_{blw}; Ratio of Width to Hieght for Brine Tank, R_{bwh}; Ratio of Length to Width for Rinse

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Water Tank, R_{rlw}: Ratio of Width to Hieght for Rinse Water Tank, R_{rwh}.

2. If Resin Parameters are known then goto 3A else Select Type of Resin and goto 3B.

3A Input: Resin Parameters (Exchange Capacity and Common Salt Value) and goto 4

3B If Type of Resin = Green Sand then Exchange Capacity = 140 meq l^{-1} and Common Salt value = 5.0; If Type of Resin = Silicious Synthetic Inorganic Zeolite then Exchange Capacity = 400 meq l^{-1} and Common Salt value = 3.0; If Type of Resin = Sulphonated Coal then Exchange Capacity = 820 meq l^{-1} and Common Salt value = 3.0; If Type of Resin = Polystyrene then Exchange Capacity = 820 meq l^{-1} and Common Salt value = 3.0;

4. Put Number of Units = 1

5. Compute: Flow Rate in Each Unit; Volume of Resin; Accumulated Hardness; Resin Bed Parameters (Diameter and Depth). Use Equation Block 039.

6. If Diameter of Resin Bed > 5 m then Put Number of Units = Number of Units + 1 and goto 5 else continue

7. Compute: Resin Bed Volume; Weight of Salt Required; Volume of Brine Water; Regeneration Time; Use Equation Block 040.

8. If Regeneration Time < 1800 s then Put Regeneration Time = 1800 s; If Regeneration Time > 2700 s then Put Regeneration Time = 2700 s

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9. Compute: Regeneration Flow Loading; Rinsing Discharge; Volume of Rinse Water. Use Equation Block 041.

10. If Volume of Rinse Water > 10 Volume of Resin then Put Volume of Rinse Water = 10 Volume of Resin;
    If Volume of Rinse Water < 3 Volume of Resin then Put Volume of Rinse Water = 3 Volume of Resin;

11. Compute: Brine Tank Parameters (Volume, Length, Width and Height); Rinsing Tank Parameters (Volume, Length, Width and Height). Use Equation Block 042.

12. Display: Flow Rate; Exchange Capacity of Resin; Common Salt Value; Regeneration Time; Regeneration Interval; Volume of Resin; Resin Bed Parameters; Brine Tank Parameters; Free Board; Rinsing Tank Parameters; Volume of Brine; Volume of Rinse Water; Regeneration Flow Loading, Number of Units.

DEFAULT PARAMETER VALUES

T = 25^{o}C; Total Influent Hardness = 10 meq l^{-1}; Service Flow Rate = 4.17.10^{-3} m s^{-1}; Rinse Water Flow Loading = 5.10^{-3} m s^{-1}; Regeneration Interval = 5000 s; Free Board =0.5 m; R_{blw} = 1; R_{bwh} = 1; R_{rlw} = 1; R_{rwh} = 1; Exchange Capacity of Resin = 140 meq l^{-1}; Common Salt Value = 5.0 kg/kg.

low Sand Filters:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Temperature, T; Diameter of Laterals; Filtration Rate; Water Depth Over Filter Bed; Ratio of Length to Width of Filter Bed, R_{lw}; Effective Size of Sand; Uniformity Coefficient of Sand; Specifications of Gravel Bed.

2. Compute: Total Surface Area of Filter; Number of Filter. Use Equation Block 043.

3. If Number of Filter is ODD then Put Number of Filter = Number of Filter + 1

4. Compute: Filter Bed Parameters (Width and Length); Number of Laterals; Spacing of Laterals; Spacing of Orifices; Diameter of Orifices; Diameter of Main Pipe; Height of Filter Box; Head Losss in Filter. Use Equation Block 044.

5. Display: Flow Rate; Filter Parameters; Lateral Parameters; Orifice Parameters; Diameter of Main Pipe; Head Loss in Filter.

DEFAULT PARAMETER VALUES

$T = 25^{o}C$; Diameter of Laterals = 0.10 m; Filtration Rate = $4.17.10^{-5}$ m s^{-1}; Water Depth Over Filter Bed = 1.0 m; Ratio of Length to Width of Filter Bed = 3; Effective Size of Sand = 3.10^{-4} m; Uniformity Coefficient of Sand = 4.5; Gravel Bed Specifications.

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7. If First Counter > 0.018 then Put Total Area of Perforations = Total Area of Orifices and goto 4 else to 8

8. Compute: Minimum Fluidization Velocity, V_f. Use Equation Block 048.

9. Compute: Reynolds Number for Fluidization Velocity, Re_f. Use Equation Block 049.

10. If $Re_f > 10$ then Put $V_f = Re_f \cdot V_f$ and goto 9

11. Compute: Wash Water Velocity; Volume of Wash Water; Number of Wash Water Trough; Discharge of Wash Water. Use Equation Block 050.

12. Compute: Depth of Wash Water Trough; Modified Width of Wash Water Trough; Second Counter. Use Equation Block 051.

13. If Second Counter > 0.01 then Put Width of Wash Water Trough = Modified Width of Wash Water Trough

14. Compute: Depth of Wash Water Trough; Length of Wash Water Tank; Width of Wash Water Tank; Height of Wash Water Tank; Total Height of Filter. Use Equation Block 052.

15. Display: Flow Rate; Specifications of Gravel and Sand Bed Parameters; Lateral Parameters; Orifice Parameters; Wash Water Trough Parameters; Wash Water Tank Pa r ameters; Diameter of Main Pipe; Terminal Head Loss.

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DEFAULT PARAMETER VALUES

T = 25 ^oC; Filtration Rate = 0.00139 m s^{-1}; Effective Size = 0.50 mm; U.C. = 3.0; ρ_{sand} = 1700 kg m^{-3}; ϵ_{sand} = 0.5; D_1 = 0.0625 m; h = 1.75 m; Water Depth Over Filter Bed = 1.5 m; R_{flw} = 1.35; R_{wlw} = 1; R_{wwh} = 1; Level of Water Pretreatment = Average; Freeboard = 0.5 m.

Pre Chlorination:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Type of Disinfectant; Hydrogen Sulphide Concentration; Iron Concentration; Manganese Concentration; Ammonia Concentration; Ratio of Length to Width of Chlorination Tank, R_{lw}; Ratio of Width to Height of Chlorination Tank, R_{wh}; Ratio of Height to Width of Channel, R_{hw}.

2. If Chlorine Dose is known

   then Input Chlorine Dose, g l^{-1}; Put Optimum Chlorine

   Dose = 12.18.10^6 . Chlorine Dose (Pounds per million gallons; Additional Chlorine Dose = 0 and goto 5

   else continue

3. Compute: Optimum Chlorine Dose by solving equation given in Equation Block 053 by Bisection Method.

4. Compute: Additional Chlorination Dose. Use Equation Block 054.

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5. Compute: Contact Time; Total Chlorine Dose; Dose of Disinfectant; Daily Disinfectant Requirement. Use Equation Block 055.

6. Compute: Tank Parameters (Length, Width and Height); Channel Parameters (Length, Width and Number); Baffle Parameters (Length and Height). Use Equation Block 056.

7. Display: Flow Rate; Type of Disinfectant; Total Chlorine Dose; Dose of Disinfectant; Daily Disinfectant Requirement; Tank Parameters; Channel Parameters; Baffle Parameters.

DEFAULT PARAMETER VALUES

Type of Disinfectant = Chlorine; Hydrogen Sulphide Concentration as H_2S = 0; Iron Concentration as Fe = 0; Manganese Concentration as Mn = 0; Ammonia Concentration as NH_3 = 0; R_{lw} = 10; R_{wh} = 2; R_{hw} = 5.

Post Chlorination:

DESIGN LOGISTICS

1. Input: Flow Rate, Q; Type of Disinfectant; Ratio of Length to Width of Chlorination Tank, R_{lw}; Ratio of Width to Height of Chlorination Tank, R_{wh}; Ratio of Height to Width of Channel, R_{hw}.

2. If Chlorine Dose is known
   then Input Chlorine Dose ($g\ l^{-1}$); Put Optimum Chlorine
   Dose = $12.18.10^6$. Chlorine Dose and goto 4
   else continue

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3. Compute: Optimum Chlorine Dose by solving equation given in Equation Block 057 by Bisection Method.

4. Compute: Contact Time; Total Chlorine Dose; Dose of Disinfectant; Daily Disinfectant Requirement. Use Equation Block 058.

5. Compute: Tank Parameters (Length, Width and Height); Channel Parameters (Length, Width and Number); Baffle Parameters (Length and Height). Use Equation Block 059.

6. Display: Flow Rate; Type of Disinfectant; Total Chlorine Dose; Dose of Disinfectant; Daily Disinfectant Requirement; Tank Parameters; Channel Parameters; Baffle Parameters.

DEFAULT PARAMETER VALUES

Type of Disinfectant = Chlorine; $R_{lw} = 10$; $R_{wh} = 2$; $R_{hw} = 5$.

Equation Blocks:

EQUATIONS

$$H_{tank} = [V_{tank}/(R_{lh}.R_{wh})]^{1/3}$$

where

$$R_{lh} = L_{tank}/H_{tank}$$

$$R_{wh} = W_{tank}/H_{tank}$$

$$V_{tank} = Q.t$$

$$t = \frac{1}{K.a.\ln[(DO_s - DO_i)/(DO_s - DO_e)]}$$

K = Reaeration Constant = $89.47X10^{-6}(1.018)^{T-20}$

a = Specific Surface Area = 6000/Nozzle Diameter

$$DO_s = 13.89 - 0.23T$$

DO_e = Specified DO in effluent IF $DO_e < 0.9DO_s$ else

$$DO_e = 0.9DO_s$$

UNITS

Q, $m^3\ s^{-1}$; H_{tank}, m; L_{tank}, m; W_{tank}, m; V_{tank}, m^3; t, s; T, ^oC; a, mm^{-1}; K, m s^{-1}; DO_s, mg l^{-1}; DO_i, mg l^{-1}; DO_e, mg l^{-1}.

Equation Block 001

EQUATIONS

Number of pipes = W_{tank}/Specified pipe spacing

Actual pipe spacing = W_{tank}/Number of pipes

$$\text{Number of nozzles per pipe} = \frac{(L_{tank} - \text{Actual pipe spacing})}{\text{Specified Nozzle spacing}}$$

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$$\text{Actual nozzle Spacing} = \frac{(L_{tank} - \text{Actual pipe spacing})}{\text{Number of nozzles per pipe}}$$

Total number of Nozzles = Number of pipes . Number of Nozzles per pipe.

UNITS

W_{tank}, m; Specified pipe spacing, m; Actual pipe spacing, m; L_{tank}, m; Specified Nozzle Spacing, m.

Equation Block 002

EQUATIONS

$$Q_{air} = \frac{1}{0.21 . 0.15} \cdot \frac{273 + T}{273} \cdot \frac{0.224}{32} \cdot pQ\ (DO_e - DO_i)$$

where

$$p = \frac{760}{760 + \dfrac{1000H_{tank}}{13.6}}$$

Q = Flow Rate of Water,

T = Temperature

$$\text{Brake Horse Power} = \frac{1.201Q_{air} 8.314(T+273)}{8.41 \ . \ 0.70} . [(\frac{p}{0.95 . 760})^{0.283} - 1]$$

UNITS

Q, $m^3\ s^{-1}$; Q_{air}, $m^3\ s^{-1}$; T, ^oC; H_{tank}, m; p, mm of Mercury; Brake Horse Power, HP.

Equation Block 003

EQUATIONS

$$DO_s = 13.89 - 0.23T$$

$$H_{crit} = \left[Q^2/(gL_{cw}^2)\right]^{1/3}$$

$$H_{diff} = 1.5H_{crit} + \text{Drop Height}$$

$$q = 3600.Q/L_{cw}$$

UNITS

DO_s, mg l^{-1}; T, ^oC; H_{crit}, m; H_{diff}, m; Q, $m^3\ s^{-1}$; g, m s^{-2};

L_{cw}, m; Drop Height, m; q, $m^2\ h^{-1}$.

Equation Block 004

EQUATIONS

$$r_{20} = \text{Exp}\left[0.0785H_{crit}^{1.31}q^{0.428}(0.3H_{diff})^{0.31}\right]$$

If $H_{diff} \leq 1.2$ and $q \leq 235$

$$r_{20} = \text{Exp}\left[0.0861H_{crit}^{0.816}q^{0.428}(0.3H_{diff})^{0.31}\right]$$

If $H_{diff} > 1.2$ and $q \leq 235$

$$r_{20} = \text{Exp}\left[5.39H_{crit}^{1.31}q^{-0.363}(0.3H_{diff})^{0.31}\right]$$

If $H_{diff} \leq 1.2$ and $q > 235$

$$r_{20} = \text{Exp}\left[5.92H_{crit}^{0.816}q^{-0.363}(0.3H_{diff})^{0.31}\right]$$

If $H_{diff} > 1.2$ and $q > 235$

$$r_T = \text{Exp}[\{1 + 0.0168(T-20)\} \ln r_{20}]$$

$$DO_e = DO_s(1 - 1/r_T) + DO_i/r_T$$

UNITS

DO_i, mg l^{-1}; DO_e, mg l^{-1}; T, ^oC; H_{crit}, m; H_{diff}, m;

Equation Block 005

EQUATIONS

Height of Cascade Wall at Upstream = $0.3H_{diff} + 1.5H_{crit}$

Height of Cascade Wall at Downstream = $0.3H_{diff}$ + Drop height

Length of Nappe = $5\ (0.3H_{diff})$

Thickness of Cascade Wall = 2 . Length of Nappe

Length of Cascade Unit = N_{cas}(Length of Nappe + Thickness of Cascade Wall) + Thickness of Cascade Wall

Width of Cascade Unit = L_{cw} + 2 . Thickness of Cascade Wall

Head loss in One Cascade Weir = Drop Height + $1.5H_{crit}$

Total Head loss in Cascade Unit = Number of Cascades . Head loss in One Cascade Weir

UNITS

All dimensions of Length and Head loss are in m.

Equation Block 006

EQUATIONS

Total Number of Nozzles = Q/[0.64 . Discharge through Nozzle]

where

Discharge through Nozzle = Area of Nozzle . Eject Velocity of Water through Nozzle

Area of Nozzle = $[\Pi(\text{Diameter of Nozzle}/1000)^2]/4$

$$\text{Eject Velocity of Water through Nozzle} = \frac{\text{g.Aeration Time}}{\text{Sin } \theta}$$

θ = Nozzle Inclination with Horizontal = 87^o.

$$\text{Aeration Time} = \frac{1}{\text{K.a.ln}\left[(DO_s - DO_i)/(DO_s - DO_e)\right]}$$

K = Reaeration Constant = $89.47.10^{-6}(1.018)^{T-20}$

a = Specific Surface Area = 6000/Diameter of Nozzle

$DO_s = 13.89 - 0.23T$

Minimum Spacing of Pipe = Aeration Time [1.2 Wind Velocity + 2 . Cosθ . Eject Velocity of Water through Nozzle]

Equation Block 007 continued on page 112

Equation Block 007 continued from page 111

Number of Pipes = Total Number of Nozzles/Number of Nozzles per Pipe

Length of Pipe = Number of Nozzles per Pipe . Spacing of Nozzles

UNITS

Area of Nozzle, m^2; Eject Velocity of Water through Nozzle, $m\ s^{-1}$; Diameter of Nozzle, m; Aeration Time, s; K, $m\ s^{-1}$; a, m^{-1}; DO_e, $mg\ l^{-1}$; DO_s, $mg\ l^{-1}$; DO_i, $mg\ l^{-1}$; Minimum Spacing of Pipe, m; Wind Velocity, $m\ s^{-1}$; Length of Pipe, m; Spacing of Nozzles, m.

Equation Block 007

EQUATIONS

Length of Tank = Length of Pipe + Minimum Spacing of Pipes

Width of Tank = Minimum Spacing of Pipes . Number of Pipes + 2 Minimum Spacing of Pipes

UNITS

Length of Tank, m; Length of Pipe, m; Minimum Spacing of Pipe, m; Width of Tank, m.

Equation Block 008

EQUATIONS

$$\text{Relative Length} = \left[\frac{v\ S_c - v_s \ Sin\theta}{v_s \ Cos\theta} \right]$$

$$\text{Transition Relative Length} = \left[\frac{0.058\ \rho_w\ v}{\mu_T} \right]$$

where

ρ_w = Mass Density of Water = 1000 $kg\ m^{-3}$

μ_T = Dynamic Viscosity = $0.0016578e^{-0.021457T}$ $kg\ s\ m^{-2}$

Equation Block 009 continued on page 113

Equation Block 009 continued from page 112

Length of Tube = 2 . Relative Length . (Side or Diameter of Tube)
If Transition Relative Length ≥ Relative Length

Length of Tube = (Relative Length + Transition Relative Length). (Side or Diameter of Tube)
If Transition Relative Length < Relative Length

Total Number of Tubes = (Total Area of Tubes)/(Side of Tube)^2
If Tube is Square

Total Number of Tubes = (Total Area of Tubes)/[π(Diameter ofTube)^2/4]
If Tube is Circular

where
Total Area of Tubes = Q/v

Number of Tubes in one Row (For Circular Tubes) = $\dfrac{\text{Width of Tank}}{\left[\text{Diameter of Tube + 2.Thickness of Tube}\right]}$

Number of Tubes in one Row (For Square Tubes) = $\dfrac{\text{Width of Tank}}{\left[\text{Side of Tube + 2 . Thickness of Tube}\right]}$

Number of Tubes in one Column = $\dfrac{\text{Total Number of Tubes}}{\left[\text{Number of Tubes in One Row}\right]}$

Length of Tank = [Number of Tubes in One Column . (Side or Diameter of Tube + 2 . Thickness of Tube) + Length of Tube . Cosθ]

Height of Tank = Length of Tube . Cosθ + Free Board + Sludge Zone Depth + Flow Distribution Zone

where Free Board = 0.5 m; Sludge Zone Depth = 1.5 m; Flow Distribution Zone = 0.5 m

UNITS

Q, $m^3\ s^{-1}$; Length of Tube, m; Total Area of Tubes, m^2; Length of Tank, m; Width of Tank, m; T, ^oC; μ_T, kg m^{-2} s; ρ_w, kg m^{-3}.

Equation Block 009

EQUATIONS

$$\text{Relative Length} = \left[\frac{v\,S_c - v_s \operatorname{Sin}\theta}{v_s \operatorname{Cos}\theta} \right]$$

$$\text{Transition Relative Length} = \left[\frac{0.058\,\rho_w\,v}{\mu_T} \right]$$

where

ρ_w = Mass Density of Water = 1000 kg m^{-3}

μ_T = Dynamic Viscosity = $0.0016578e^{-0.021457T}$ kg m^{-2} s

Length of Plate = 2 . Relative Length . (Spacing between Plates)
If Transition Relative Length ≥ Relative Length

Length of Plate = (Relative Length + Transition Relative Length). (Spacing between Plates)

If Transition Relative Length < Relative Length

Width of Plate = Width of Tank

$$\text{Number of Plates} = \frac{\text{Total Area of Plates}}{\text{Spacing between Plates . Width of Tank}}$$

where
Total Area of Plates = Q/Flow Velocity through Plates

Length of Tank = [Number of Plates . (Spacing between Plates + Plate Thickness)] + Length of Plate . Cosθ

Height of Tank = Length of Plate . Cosθ + Free Board + Sludge Zone Depth + Flow Distribution Zone

where
Free Board = 0.5 m
Sludge Zone Depth = 1.5 m
Flow Distribution Zone = 0.5 m

UNITS

Length of Plate, m; Total Area of Plates, m^2; Length of Tank, m; Width of Tank, m; T, ^oC; μ_T, kg m^{-2} s; ρ_w, kg m^{-3}; θ, degrees.

Equation Block 010

EQUATIONS

$$\text{Settling Velocity} = (g/18).(\rho_s - \rho_w).(d_s^2/\mu_T) \quad \text{If } Re < 1$$

$$\text{Settling Velocity} = \left[\frac{4.g.(\rho_s - \rho_w)}{3.\text{Drag Coefficient}.\mu_T}\right]^{1/2} \quad \text{If } 1<Re<10^3$$

$$\text{Settling Velocity} = \left[\frac{3.3\ g.(\rho_s - \rho_w)\ d_s}{\rho_w}\right]^{1/2} \quad \text{If } 10^3<Re<10^4$$

where

$$\text{Drag Coefficient} = \frac{24}{Re} + \frac{3}{Re^{0.5}} + 0.34$$

g = Acceleration due to Gravity = 981 cm s^{-2}

ρ_s = Mass Density of Settling Particles = 2650 kg m^{-3}

ρ_w = Mass Density of Water = 1000 kg m^{-3}

Re = Reynolds Number = [Settling Velocity . $d_s.\rho_w/\mu_T$]

$\mu_T = 0.0016578e^{-0.02145T}$

UNITS

Settling Velocity, m s^{-1}; g, cm s^{-2}; ρ_s, kg m^{-3}; d_s, cm; T, ^oC; μ_T, kg m^{-2} s; ρ_w, kg m^{-3}.

Equation Block 011

EQUATIONS

Flow in Each Tank = Q/Number of Tanks

Width of Tank = R_{wh} . Height of Tank

Length of Settling Zone of Tank = Area of Tank/Width of Tank

where

Area of Tank = Flow in Each Tank / Surface Overflow Rate

UNITS

Q, m^3 s^{-1}; Flow in Each Tank, m^3 s^{-1}; Width of Tank, m; Length of Tank, m; Area of Tank, m^2; Surface Overflow Rate, m s^{-1}.

Equation Block 012

EQUATIONS

Length of Outlet Zone = 0.2 Length of Tank

Width of Lateral Effluent Launder = 0.1 . Length of Outlet Zone

$$\text{Weir Loading} = \frac{\text{Flow in Each Tank}}{\left[\text{Width of Tank} + \text{Number of Lateral Launders} \,.\, (\text{Width of Lateral Effluent Launder} + 2 \,.\, \text{Length of Outlet Zone})\right]}$$

UNITS

Flow in Each Tank, $m^3\ s^{-1}$; Length of Outlet Zone, m; Width of Lateral Effluent Launder, m; Weir Loading, $m^2\ s^{-1}$.

Equation Block 013

EQUATIONS

Number of Ports = [Width of Tank . Height of Tank]/[Specified Spacing of Ports]

Diameter of Ports = $[4 \,.\, \text{Flow in Each Tank}/(\pi \text{Number of Ports} \,.\, \text{Velocity in Ports})]^{1/2}$

Width of Main Effluent Launder = R_{wet} . Width of Tank

where

R_{wet} = Ratio of Width of Main Effluent Launder to Width of Tank = 0.1

Depth of Main Effluent Launder = $3\,[\text{Flow in Each Tank}/(2 \,.\, g^{0.5} \,.\, \text{Width of Main Effluent Launder})]^{2/3}$ + Free Fall

Depth of Lateral Effluent Launder = $3[4 \,.\, \text{Flow in Each Tank}/(2 \,.\, g^{0.5} \,.\, \text{Number of Lateral Effluent Launder} \,.\, \text{Width of Lateral Effluent Launder})]^{2/3}$ + Free Fall

where

Free Fall = 0.3 m for Main Effluent Launder

Free Fall = 0.1 m for Lateral Effluent Launder

Depth of Influent Launder = Height of Tank . Ratio of Depth of Influent Launder to Depth of Tank

where

Ratio of Depth of Influent Launder to Depth of Tank = 0.25

Equation Block 014 continued on page 117

Equation Block 014 continued from page 116

Width of Influent Launder = Ratio of Width of Influent Launder to Width of Tank . Width of Tank

where

Ratio of Width of Influent Launder to Width of Tank = 0.1

Length of Tank = Length of Settling Zone of Tank + Length of Outlet Zone + Width of Influent Launder

UNITS

Height of Tank, m; Width of Tank, m; Length of Tank, m; Spacing of Ports, m; Flow in Each Tank, $m^3\ s^{-1}$; Velocity in Ports, $m\ s^{-1}$; Width of Main Effluent Launder, m; Depth of Main Effluent Launder, m; Width of Influent Launder, m; Free Fall, m; Width of Influent Launder, m; Depth of Influent Launder, m; g, $cm\ s^{-2}$.

Equation Block 014

EQUATIONS

Flow in Each Tank = Q/Number of Tanks

$$\text{Diameter of Tank} = \left[\frac{4.\text{Flow in Each Tank}}{\pi.\text{Surface Overflow Rate}}\right]^{1/2}$$

Diameter of Baffle Wall = R_{bt} . Diameter of Tank

where

R_{bt} = Ratio of Diameter of Baffle Wall to Diameter of Tank = 0.24

$$\text{Number of Ports} = \left[\frac{\pi.\text{Height of Tank . Diameter of Baffle Wall}}{2.(\text{Spacing of Ports})^2}\right]$$

$$\text{Diameter of Ports} = \left[\frac{\text{Total Area of Ports} - \pi(\text{Diameter of Baffle Wall})^2}{4.\text{Number of Ports}}\right]^{1/2}$$

where

Total Area of Ports = Flow in Each Tank/Velocity in Port

Revised Diameter of Tank =

$$\left[(\text{Diameter of Baffle Wall})^2 + (\text{Computed Diameter of Tank})^2\right]^{1/2}$$

Equation Block 015 continued on page 118

Equation Block 015 continued from page 117

Weir Loading = Flow in Each Tank/[π . Revised Diameter of Tank]

Depth of Effluent Launder =

$$3 \; . \; \text{Effluent Launder}\left[\frac{\text{Flow in Each Tank}}{2.g^{1/2}.\text{Width of Effluent Launder}}\right]^{2/3} + \text{Free board}$$

where

Width of Effluent Launder = Revised Diameter of Tank/R_{dw}

R_{dw} = Ratio of Diameter of Tank to Width of Effluent Launder
= 20

Free board = 0.3 m

$$\text{Diameter of Influent Pipe} = \left[\frac{4.\text{Flow in Each Tank}}{\pi.\text{Velocity in Each Port}}\right]^{1/2}$$

UNITS

Height of Tank, m; Diameter of Tank, m; Diameter of Baffle Wall, m; Spacing of Ports, m; Q, $m^3\ s^{-1}$; Velocity in Ports, $m\ s^{-1}$; Width of Effluent Launder, m; Diameter of Influent Pipe, m; Free Fall, m.

Equation Block 015

EQUATIONS

Flow in Each Tank = Q/Number of Tanks

$$\text{Diameter of Tank} = \left[\frac{4.\text{Flow in Each Tank}}{\pi.\text{Surface Overflow Rate}}\right]^{1/2}$$

Width of Effluent Launder = R_{et}. Diameter of Tank

where

R_{et}= Ratio of Width of Effluent Launder to Diameter of Tank
= 0.05

Height of Port Opening = Flow in Each Tank/(Velocity in Port. π . Diameter of Tank)

Equation Block 016 continued on page 119

Equation Block 016 continued from page 118

Weir Loading = Flow in Each Tank/[π . Revised Diameter of Tank]

Depth of Effluent Launder

$$= 3 \; . \; \text{Effluent Launder}\left[\frac{\text{Flow in Each Tank}}{2 \; . \; g^{1/2} . \; \text{Width of Effluent Launder}}\right]^{2/3} + \text{Free board}$$

where

Width of Effluent Launder = Revised Diameter of Tank/R_{dw}

R_{dw} = Ratio of Diameter of Tank to Width of Effluent Launder

= 20

Free board = 0.3 m

$$\text{Diameter of Influent Pipe} = \left[\frac{4.\text{Flow in Each Tank}}{\pi.\text{Velocity in Each Port}}\right]^{1/2}$$

UNITS

Height of Tank, m; Diameter of Tank, m; ; Flow in Each Tank, $m^3 \; s^{-1}$; Velocity in Ports, m s^{-1}; Width of Effluent Launder, m; Diameter of Influent Pipe, m; Free Fall, m; Depth of Effluent Launder, m.

Equation Block 016

EQUATIONS

Volume of Tank = Power Input per Unit Flow Rate . $Q/(\mu_T \; . \; G^2)$

where

$\mu_T = 0.0016578e^{-0.02145T}$

Height of Tank = (Volume of Tank/R_{lh})$^{1/3}$

Length of Tank = R_{lh}. Height of Tank

Width of Tank = Length of Tank for Square Tank

Length of Blade = R_{lbwt}. Width of Tank

where

R_{lbwt}= Ratio of Length of Blade to Width of Tank = 0.8

Equation Block 017 continued on page 120

Equation Block 017 continued from page 119

Height of Blade = Length of Blade/R_{blw}

$$\text{Revolution per minute} = 60\left[\frac{2\ n\ \mu_T\ \text{Volume of Tank}.G^2}{C_d A_p \rho_w \pi(\text{Length of Blade})^3}\right]^{1/3}$$

where

n = Number of Blades = 4

C_d = Coefficient of Drag = 1.8

A_p = Length of Blade . Height of Blade

ρ_w = Mass Density of Water = 1000 kg m^{-3}

$$\text{Motor Power} = \frac{\text{Power Input per Unit Flow . Q}}{\text{Efficiency of Motor and Drive}}$$

UNITS

Q, $m^3\ s^{-1}$; T, ^oC; G, s^{-1}; Volume of Tank, m^3; Height of Tank, m; Length of Tank, m; Width of Tank, m; Length of Blade, m; Width of Blade, m; Revolution per minute, min^{-1}; Power Input per Unit Flow Rate, watt m^{-3}s; Motor Power, watt.

Equation Block 017

EQUATIONS

Volume of Tank = Q . Hydraulic Retention Time

Diameter of Tank = [4.Volume of Tank . $R_{dd}/\pi]^{1/3}$

where

R_{dd} = Specified Ratio of Diameter to Depth of Tank

Input Power = $G^2\ \mu_T$ Volume of Tank

$\mu_T = 0.0016578e^{-0.02145T}$

G = Velocity Gradient

Length of Stator = R_{sld}. Diameter of Tank

Length of Blade = R_{bld}. Diameter of Tank

Equation Block 018 continued on page 121

Equation Block 018 continued from page 120

Height of Blade = Length of Blade/R_{blw}

where

R_{sld}= Ratio of Length of Stator to Diameter of Tank = 0.1

R_{bld}= Ratio of Length of Blade to Diameter of Tank = 0.4

$$\text{Revolution per minute} = 60\left[\frac{2\ \mu_T \text{Volume of Tank}.G^2}{nC_d A_p \rho_w \pi(\text{Length of Blade})^3}\right]^{1/3}$$

where

n = Number of Blades = 6

C_d = Coefficient of Drag = 1.8

A_p = Length of Blade . Height of Blade

ρ_w = Mass Density of Water = 1000 kg m^{-3}

$$\text{Motor Power} = \frac{\text{Input Power}}{\text{Efficiency of Motor and Drive}}$$

UNITS

Q, $m^3\ s^{-1}$; T, ^oC; G, s^{-1}; Hydraulic Retention Time, s; Volume of Tank, m^3; Depth of Tank, m; Diameter of Tank, m; Length of Blade, m; Height of Blade, m; Revolution per minute, min^{-1}; Input Power, watt; Motor Power, watt.

Equation Block 018

EQUATIONS

Volume of Tank = Q . Hydraulic Retention Time

$$\text{Width of Tank} = \left[\frac{\text{Ratio of Width to Height of Tank . VolumeofTank}}{\text{Ratio of Length to Width of Tank}}\right]^{1/}$$

$$\text{Height of Tank} = \left[\frac{\text{Width of Tank}}{\text{Ratio of Width to Height of Tank}}\right]$$

Equation Block 019 continued on page 122

Equation Block 019 continued from page 121

$$\text{Length of Tank} = \left[\frac{\text{Volume of Tank}}{\text{Height of Tank.Width of Tank}}\right]$$

$$\text{Width of Channel} = \left[\frac{Q}{\text{Width of Tank . Velocity in Channel}}\right]$$

where Velocity in Channel = 0.6 m s^{-1}

UNITS

Q, m^3 s^{-1}; Hydraulic Retention Time, s; Volume of Tank, m^3; Height of Tank, m; Width of Tank, m; Length of Tank, m; Width of Channel, m; Velocity through Channel, m s^{-1}.

Equation Block 019

EQUATIONS

Number of Channels = Int(Length of Tank/Width of Channel) + 1

Length of Channel = Height of Tank

Length of Baffle = Length of Channel - Width of Channel/2

Velocity in Channel = Q/[Width of Channel . Width of Tank]

Velocity in Slots = 2 . Velocity in Channel

UNITS

Q, m^3 s^{-1}; Height of Tank, m; Width of Tank, m; Length of Tank, m; Length of Channel, m; Width of Channel, m; Velocity in Channel, m s^{-1}; Velocity in Slots, m s^{-1}.

Equation Block 020

EQUATIONS

Head loss in Tank

= 0.0153(G . Hydraulic Retention Time)$^{0.47}$ + Number of Channels . Length of Channel . Slope of Channel

Equation Block 021 continued on page 123

Equation Block 021 continued from page 122

where

G = Velocity Gradient = $2791.26(\text{Hydraulic Retention Time})^{0.346}$

Slope of Channel = 1/50

$$\text{Water Head Over Weir} = \left[\frac{3 \,.\, Q}{2.C_d(2g)^{0.5}\text{Width of Tank}}\right]^{2/3}$$

where

C_d = Discharge Coefficient = 0.6

g = Acceleration due to gravity = 9.81 m s^{-2}

UNITS

Q, $m^3\ s^{-1}$; Hydraulic Retention Time, s; Head loss in Tank, m; G, s^{-1}; Width of Tank, m; Length of Channel, m; Width of Channel, m; Water Head Over Weir, m.

Equation Block 021

EQUATIONS

Volume of Tank = Q . Hydraulic Retention Time

$$\text{Width of Tank} = \left[\frac{\text{Ratio of Width to Height of Tank . VolumeofTank}}{\text{Ratio of Length to Width of Tank}}\right]^{1/}$$

$$\text{Height of Tank} = \left[\frac{\text{Width of Tank}}{\text{Ratio of Width to Height of Tank}}\right]$$

$$\text{Length of Tank} = \left[\frac{\text{Volume of Tank}}{\text{Height of Tank.Width of Tank}}\right]$$

$$\text{Width of Channel} = \left[\frac{Q}{\text{Height of Tank.Velocity in Channel}}\right]$$

where Velocity in Channel = 0.6 m s^{-1}

Equation Block 022 continued on page 124

Equation Block 022 continued from page 123

UNITS

Q, $m^3\ s^{-1}$; Hydraulic Retention Time, s; Volume of Tank, m^3; Height of Tank, m; Width of Tank, m; Length of Tank, m; Width of Channel, m; Velocity through Channel, $m\ s^{-1}$.

Equation Block 022

EQUATIONS

Number of Channels = Int(Length of Tank/Width of Channel) + 1

Length of Channel = Width of Tank

Length of Baffle = Length of Channel - Width of Channel/2

Velocity in Channel = Q/[Width of Channel . Height of Tank]

Velocity in Slots = 2 . Velocity in Channel

UNITS

Q, $m^3\ s^{-1}$; Height of Tank, m; Width of Tank, m; Length of Tank, m; Length of Channel, m; Width of Channel, m; Velocity in Channel, $m\ s^{-1}$; Velocity in Slots, $m\ s^{-1}$.

Equation Block 023

EQUATIONS

Head loss in Tank

$$= 0.0153(G \cdot \text{Hydraulic Retention Time})^{0.47} + \text{Number of Channels} \cdot \text{Length of Channel} \cdot \text{Slope of Channel}$$

where

$$G = \text{Velocity Gradient} = 2791.26(\text{Hydraulic Retention Time})^{0.346}$$

$$\text{Slope of Channel} = 1/50$$

$$\text{Water Head Over Weir} = \left[\frac{3 \cdot Q}{2 \cdot C_d (2g)^{0.5}\,\text{Width of Channel}}\right]^{2/3}$$

Equation Block 024 continued on page 125

Equation Block 024 continued from page 124

where

C_d = Discharge Coefficient = 0.6

g = Acceleration due to gravity = 9.81 m s^{-2}

UNITS

Q, m^3 s^{-1}; Hydraulic Retention Time, s; Head loss in Tank, m; G, s^{-1}; Width of Tank, m; Length of Channel, m; Width of Channel, m; Water Head Over Weir, m.

Equation Block 024

EQUATIONS

Volume of Tank = Q . Hydraulic Retention Time

Height of Tank = (Volume of Tank/R_{lh})$^{1/3}$

Length of Tank = R_{lh} . Height of Tank

Width of Tank = Length of Tank for Square Tank

Length of Blade = R_{lbwt} . Width of Tank

where

R_{lbwt} = Ratio of Length of Blade to Width of Tank = 0.4

Height of Blade = Length of Blade/R_{lw}

Power Input = μ_T. G^2 Volume of Tank

where

$\mu_T = 0.0016578e^{-0.02145T}$

T = Temperature ^oC

Area of One Blade = Length of Blade . Height of Blade

$$\text{Revolution per minute} = 60\left[\frac{2\ \text{Power Input}}{n\ C_d A_p \rho_w \pi (\text{Length of Blade})^3}\right]^{1/3}$$

where

n = Number of Blades = 4

C_d = Coefficient of Drag = 1.8

Equation Block 025 continued on page 126

Equation Block 025 continued from page 125

A_p = Length of Blade . Height of Blade

ρ_w = Mass Density of Water = 1000 kg m^{-3}

$$\text{Motor Power} = \frac{\text{Power Input}}{\text{Efficiency of Motor and Drive}}$$

UNITS

Q, m^3 s^{-1}; T, ^oC; G, s^{-1}; Volume of Tank, m^3; Height of Tank, m; Length of Tank, m; Width of Tank, m; Length of Blade, m; Width of Blade, m; Revolution per minute, min^{-1}; Power Input per Unit Flow, watt m^{-3} s; Motor Power, watt.

Equation Block 025

EQUATIONS

Volume of Tank = Q . Hydraulic Retention Time

$$\text{Width of Tank} = \left[\frac{\text{Ratio of Width to Height of Tank . Volume of Tank}}{\text{Ratio of Length to Width of Tank}}\right]^{1/}$$

$$\text{Height of Tank} = \left[\frac{\text{Width of Tank}}{\text{Ratio of Width to Height of Tank}}\right]$$

$$\text{Length of Tank} = \left[\frac{\text{Volume of Tank}}{\text{Height of Tank . Width of Tank}}\right]$$

UNITS

Q, m^3 s^{-1}; Volume of Tank, m^3; Height of Tank, m; Length of Tank, m; Width of Tank, m.

Equation Block 026

EQUATIONS

Diameter of Outermost Paddles = Tip Velocity/(2 π Number of Revolutions per second)

Equation Block 027 continued on page 127

Equation Block 027 continued from page 126

UNITS

Diameter of Outermost Paddles, m; Number of Revolutions per second, s^{-1}; Tip Velocity, m s^{-1}.

Equation Block 027

EQUATIONS

Input Power = $\mu_T \cdot G^2$ Volume of Tank

where

G = Specified Velocity Gradient

$\mu_T = 0.0016578e^{-0.02145T}$

T = Temperature

Number of Shaft = 0.8 . Length of Tank/Length of Shaft

$$\text{Area of Paddles} = \left[\frac{2\ \mu_T\ \text{Volume of Tank}\ .\ G^2}{C_d\ \ \rho_w\ (0.75\ \text{Tip Velocity})^3}\right]$$

where

C_d= Coefficient of Drag = 1.8

ρ_w = Mass Density of Water = 1000 kg m^{-3}

$$\text{Width of Paddles} = \frac{\text{Area of Paddles}}{\text{Length of Shaft . Number of Paddles per Shaft}}$$

$$\text{Motor Power} = \frac{\text{Input Power}}{\text{Efficiency of Motor and Drive}}$$

Revolution per minute = 60 . Number of Revolutions per second

UNITS

Q, $m^3\ s^{-1}$; T, ^oC; G, s^{-1}; Volume of Tank, m^3; Height of Tank, m; Length of Tank, m; Width of Tank, m; Length of Blade, m; Width of Blade, m; Revolution per minute, min^{-1}; Power Input per Unit Flow, watt m^{-3} s; Motor Power, watt.

Equation Block 28

EQUATIONS

Volume of Tank = Q . Hydraulic Retention Time

Diameter of Tank = $[4 \,.\, \text{Volume of Tank} \,.\, R_{dd}/\pi]^{1/3}$

Depth of Tank = Diameter of Tank/R_{dd}

where

R_{dd} = Specified Ratio of Diameter to Depth of Tank

Power Input = $G^2 \mu_T$ Volume of Tank

$\mu_T = 0.0016578e^{-0.02145T}$

G = Specified Velocity Gradient

Length of Blade = R_{bld} . Diameter of Tank

Width of Blade = Length of Blade/R_{blw}

where

R_{bld} = Ratio of Length of Blade to Diameter of Tank = 0.4

R_{blw} = Ratio of Length of Blade to Width of Blade = 5

Area of Blade = Width of Blade . Length of Blade

UNITS

Q, $m^3\ s^{-1}$; T, ^oC; G, s^{-1}; Hydraulic Retention Time, s; Volume of Tank, m^3; Depth of Tank, m; Diameter of Tank, m; Length of Blade, m; Width of Blade, m; Power Input, watt.

Equation Block 029

EQUATIONS

$$\text{Revolution per second} = \left[\frac{2\ \mu_T\ \text{Volume of Tank}\ .\ G^2}{n\ C_d\ A_p\ \rho_w\ \pi\ (\text{Length of Blade})^3}\right]^{1/3}$$

where

n = Number of Blades = 6

C_d = Coefficient of Drag = 1.8

A_p = Length of Blade . Height of Blade

ρ_w = Mass Density of Water = 1000 kg m^{-3}

Equation Block 030 continued on page 129

Equation Block 030 continued from page 128

$$\text{Motor Power} = \frac{\text{Power Input}}{\text{Efficiency of Motor and Drive}}$$

UNITS

G, s^{-1}; Volume of Tank, m^3; Length of Blade, m; Width of Blade, m; Revolution per second, s^{-1}; Power Input, watt; Motor Power, watt.

Equation Block 030

EQUATIONS

$$\text{Volume of Tank} = Q\ .\ \text{Hydraulic Retention Time}$$

$$\text{Width of Tank} = \left[\frac{\text{Ratio of Width to Height of Tank}\ .\ \text{Volume of Tank}}{\text{Ratio of Length to Width of Tank}}\right]^{1/}$$

$$\text{Height of Tank} = \left[\frac{\text{Width of Tank}}{\text{Ratio of Width to Height of Tank}}\right]$$

$$\text{Length of Tank} = \left[\frac{\text{Volume of Tank}}{\text{Height of Tank}\ .\ \text{Width of Tank}}\right]$$

UNITS

Q, $m^3\ s^{-1}$; Hydraulic Retention Time, s; Volume of Tank, m^3; Height of Tank, m; Width of Tank, m; Length of Tank, m.

Equation Block 031

EQUATIONS

$$\text{Width of Channel} = \left[\frac{Q}{\text{Width of Tank}\ .\ \text{Velocity in Channel}}\right]$$

where Velocity in Channel = 0.6 m s^{-1}

Number of Channels = Int(Length of Tank/Width of Channel) + 1

Equation Block 032 continued on page 130

Equation Block 032 continued from page 129

Length of Channel = Height of Tank

Length of Baffle = Length of Channel - Width of Channel/2

Velocity in Channel = Q/[Width of Channel . Width of Tank]

Velocity in Slots = 2 . Velocity in Channel

Head loss in Channels = [{ Number of Channels . (Velocity in Channel)^2} + { (Number of Channels - 1)(Velocity in Slots)^2}] / 2g

$$\text{Velocity Gradient} = \left[\frac{\rho \;.\; g \;.\; \text{Headloss in Channel}}{\mu_T \; t}\right]^{1/2}$$

where

ρ = Mass Density of Water = 1000 kg m^{-3}

$\mu_T = 0.0016578e^{-0.02145T}$

UNITS

Q, m^3 s^{-1}; Height of Tank, m; Width of Tank, m; Length of Tank, m; Width of Channel, m; Velocity in Channel, m s^{-1}; Velocity in Slots, m s^{-1}; Head loss in Channels, m s^{-1}; Velocity Gradient, s^{-1}; Length of Baffle, m.

Equation Block 032

EQUATIONS

Head loss in Tank = Head loss in Channels + {Number of Channels . . Length of Channel . Slope of Channel}

where

Slope of Channel = 1/50

$$\text{Head Over Baffle} = \left[\frac{3 \;.\; Q}{2 \;.\; C_d (2g)^{0.5} \text{Width of Tank}}\right]^{2/3}$$

where

C_d = Discharge Coefficient = 0.6

Equation Block 033 continued on page 131

Equation Block 033 continued from page 130

g = Acceleration due to gravity = 9.81 m s^{-2}

UNITS

Head loss in Tank, m; Head loss in Channels, m; Width of Tank, m; Length of Channel, m; Width of Channel, m; Head Over Baffle, m.

Equation Block 033

EQUATIONS

Volume of Tank = Q . Hydraulic Retention Time

$$\text{Width of Tank} = \left[\frac{\text{Ratio of Width to Height of Tank . VolumeofTank}}{\text{Ratio of Length to Width of Tank}}\right]^{1/3}$$

$$\text{Height of Tank} = \left[\frac{\text{Width of Tank}}{\text{Ratio of Width to Height of Tank}}\right]$$

$$\text{Length of Tank} = \left[\frac{\text{Volume of Tank}}{\text{Height of Tank . Width of Tank}}\right]$$

UNITS

Q, m^3 s^{-1}; Hydraulic Retention Time, s; Volume of Tank, m^3; Height of Tank, m; Width of Tank, m; Length of Tank, m.

Equation Block 034

EQUATIONS

$$\text{Width of Channel} = \left[\frac{Q}{\text{Hieght of Tank . Velocity in Channel}}\right]$$

where Velocity in Channel = 0.6 m s^{-1}

Number of Channels = Int(Length of Tank/Width of Channel) + 1

Equation Block 035 continued on page 132

Equation Block 035 continued from page 131

Length of Channel = Width of Tank

Length of Baffle = Length of Channel - Width of Channel/2

Velocity in Channel = Q/[Width of Channel . Height of Tank]

Velocity in Slots = 2 . Velocity in Channel

Head loss in Channels = [{Number of Channels . (Velocity in Channel)^2} + {(Number of Channels - 1)(Velocity in Slots)^2}] / 2g

$$\text{Velocity Gradient} = \left[\frac{\rho \cdot g \cdot \text{Headloss in Channel}}{\mu_T\ t}\right]^{1/2}$$

where

ρ = Mass Density of Water = 1000 kg m^{-3}

$\mu_T = 0.0016578e^{-0.02145T}$

UNITS

Q, m^3 s^{-1}; Height of Tank, m; Width of Tank, m; Length of Tank, m; Width of Channel, m; Velocity in Channel, m s^{-1}; Velocity in Slots, m s^{-1}; Head loss in Channels, m s^{-1}; Velocity Gradient, s^{-1}; Length of Baffle, m.

Equation Block 035

EQUATIONS

Head loss in Tank = [Head loss in Channels + {Number of Channels . Length of Channel . Slope of Channel}]

where
Slope of Channel = 1/15

$$\text{Head Over Baffle} = \left[\frac{3 \cdot Q}{2 \cdot C_d (2g)^{0.5}\ \text{Width of Channel}}\right]^{2/3}$$

where

C_d = Discharge Coefficient = 0.6

Equation Block 036 continued on page 133

Equation Block 036 continued from page 132

g = Acceleration due to gravity = $9.81\ m\ s^{-2}$

UNITS

Head loss in Tank, m; Head loss in Channels, m; Width of Tank, m; Length of Channel, m; Width of Channel, m; Head Over Baffle, m.

Equation Block 036

EQUATIONS

$$X = [H_2 - (H_e - 35)]/(H_2 - 10)$$

if $[H_2 - (H_e - 35)]/(H_2 - 10) > 0.01$

else $X = 0$

where X = Fraction of influent flow to be completely treated

UNITS

H_2, mg l^{-1} as $CaCO_3$; H_e, mg l^{-1} as $CaCO_3$.

Equation Block 037

EQUATIONS

$$L_1 = C + H_1 + 2\ H_2 + [A - (H_1 + H_2)] + \text{Excess Lime if } A > (H_1 + H_2)$$

$$L_1 = C + A + H_2 + \text{Excess Lime if } A < (H_1 + H_2) \text{ and } H_1 > A$$

$$L_1 = C + H_1 + 2[A - H_1] + [H_1 + H_2 - A] + \text{Excess Lime}$$

if $A < (H_1 + H_2)$ and $H_1 \leq A$

where Excess Lime = 50 mg l^{-1} as $CaCO_3$

$S_1 = 0$ if $A > (H_1 + H_2)$

$S_1 = (H_1 - A) + H_2$ if $A < (H_1 + H_2)$ and $H_1 > A$

$S_1 = H_1 + H_2 - A$ if $A < (H_1 + H_2)$ and $H_1 \leq A$

$L_2 = [B_1 + B_2 + (1-X)H_1]/X$

Equation Block 038 continued on page 134

Equation Block 038 continued from page 133

where

$B_1 = C(1-X) - 50X$

$B_2 = [A - (H_1 + H_2)](1-X)$ if $A > H_1 + H_2$

$B_2 = 0$ if $A \leq H_1 + H_2$

$S_2 = (1-X)(H_1 - A)/X$

Total Lime Dose = $(74/100).(X.Q.L_1 + Q.L_2)$

Total Soda Dose = $(106/100).(X.Q.S_1 + Q.S_2)$

Daily Lime Requirement = 24 (3600) Total Lime Dose

Daily Soda Requirement = 24 (3600) Total Soda Dose

UNITS

L_1, L_2, S_1, S_2, C, H_1, H_2, H_e, mg l^{-1} as $CaCO_3$; Total Lime Dose, kg s^{-1}; Total Soda Dose, kg s^{-1}; Daily Lime Requirement, kg; Daily Soda Requirement, kg.

Equation Block 038

EQUATIONS

Flow in Each Unit = Q/Number of Units

Accumulated Hardness = Regeneration Time Interval . Flow in Each Unit . Total Hardness)/1000

Volume of Resin = Accumulated Hardness / (1000 . Exchange Capacity)

Diameter of Resin Bed = $[4 \cdot \text{Area of Bed}/\pi]^{1/2}$

where

Area of Bed = Flow in Each Unit/Service Flow Rate

Depth of Resin Bed = Volume of Resin/Area of Bed

UNITS

Flow in Each Unit, $m^3\ s^{-1}$; Q, $m^3\ s^{-1}$; Accumulated Hardness, meq l^{-1}; Total Hardness, meq l^{-1}; Exchange Capacity, meq l^{-1};

Equation Block 039 continued on page 135

Equation Block 039 continued from page 134

Regeneration Time Interval, s; Service Flow Rate, m s^{-1}; Volume of Resin, m^3; Diameter of Resin Bed, m; Area of Bed, m^2; Depth of Resin Bed, m;

Equation Block 039

EQUATIONS

Volume of Resin Bed = [π(Diameter of Resin Bed)^2 . Depth of Resin Bed]/4

Weight of Salt Required = 50.10^{-3}Accumulated Hardness/Common Salt Value

Volume of Brine Water = 0.01 Weight of Salt Required (For 10% Salt Solution)

Regeneration Time = Volume of Brine Water/(0.15 Volume of Resin Bed)

UNITS

Accumulated Hardness, meq l^{-1}; Common Salt Value, kg/kg; Service Flow Rate, m s^{-1}; Regeneration Time, s; Weight of Salt Required, kg; Volume of Brine Water, m^3; Volume of Resin Bed, m^3; Diameter of Resin Bed, m; Area of Bed, m^2; Depth of Resin Bed, m;

Equation Block 040

EQUATIONS

Regeneration Flow Loading = Volume of Brine Water/Regeneration Time

Rinsing Discharge = Rinsing Flow Loading . Area of Bed

Volume of Rinse Water = Rinsing Discharge . Rinsing Time

UNITS

Regeneration Flow Loading, m s^{-1}; Regeneration Time, s; Rinsing Discharge, m^3 s^{-1}; Rinsing Flow Loading, m s^{-1}; Area of Bed, m^2; Volume of Rinse Water, m^3; Rinsing Time, s.

Equation Block 041

EQUATIONS

Volume of Brine Tank = 3 . Volume of Brine Water

Length of Brine Tank = $(R_{blw}^2 \cdot R_{bwh} \cdot \text{Volume of Brine Tank})^{1/3}$

Width of Brine Tank = Length of Brine Tank/R_{blw}

Height of Brine Tank = Width of Brine Tank/R_{bwh}

Volume of Rinsing Tank = 6 . Volume of Rinse Water

Length of Rinsing Tank = $(R_{rlw}^2 \cdot R_{rwh} \cdot \text{Volume of Rinsing Tank})^{1/3}$

Width of Rinsing Tank = Length of Rinsing Tank/R_{rlw}

Height of Rinsing Tank = Width of Rinsing Tank/R_{rwh}

UNITS

Volume of Brine Tank, m^3; Volume of Brine Water, m^3; Length of Brine Tank, m; Width of Brine Tank, m; Height of Brine Tank, m; Volume of Rinsing Tank, m^3; Volume of Rinse Water, m^3; Length of Rinsing Tank, m; Width of Rinsing Tank, m; Height of Rinsing Tank, m;

Equation Block 042

EQUATIONS

Total Surface Area of Filters = Q/Filtration Rate

Number of Filter = $[3600 \cdot Q/4]^{1/2}$

Surface Area of One Filter Bed = Total Surface Area of Filters/Number of Filter

UNITS

Q, $m^3\ s^{-1}$; Total Surface Area of Filters, m^2; Filtration Rate, $m\ s^{-1}$.

Equation Block 043

EQUATIONS

Width of Filter Bed = [Surface Area of One Filter Bed/R_{lw}]$^{1/2}$

Length of Filter Bed = R_{lw} . Width of Filter Bed

Number of Laterals= (4 . Total Area of Laterals)/[π(Diameter of Lateral)^2]

where

Total Area of Laterals = R_{lp} . Total Area of Perforations

Total Area of Perforations = R_{pf} . Total Surface Area of Filters

R_{lp} = Ratio of Area of Laterals to Area of Perforations = 3

R_{pf} = Ratio of Area of Perforations to Area of Filter = 0.003

Spacing of Lateral = Length of Filter Bed/Number of Laterals

Spacing of Orifices = R_{ol} . Spacing of Lateral

where

R_{ol} = Ratio of Spacing of Orifices to Spacing of Lateral

Diameter of Orifices = [4 . Area of Orifices/π]$^{1/2}$

where

Area of Orifices = [Total Area of Perforations . Spacing of Orifices]/[Number of Laterals . Width of Filter Bed]

Diameter of Main Pipes = [4 . Area of Main Pipes/π]$^{1/2}$

where

Area of Main Pipes = R_{ml}. Total Area of Laterals

R_{ml}= Ratio of Area of Main Pipes to Total Area of Laterals = 1.75

Height of Filter Bed = Diameter of Main Pipes + Depth of Gravel Bed + Depth of Sand Bed + Free board + Water Depth Over Filter Bed.

UNITS

Length of Filter Bed, m; Width of Filter Bed, m; Height of Filter Bed, m; Diameter of Lateral, m; Spacing of Lateral, m; Spacing of Orifices, m ; Diameter of Orifices, m; Diameter of Main Pipes, m ; Area of Orifices, m^2; Area of Main Pipes, m^2;

Equation Block 044 continued on page 138

Equation Block 044 continued from page 137
Total Area of Laterals, m^2; Total Area of Perforations, m^2; Total Surface Area of Filters, m^2 ; Depth of Gravel Bed, m; Depth of Sand Bed, m ; Free board, m; Water Depth Over Filter Bed, m.

Equation Block 044

EQUATIONS

Total Area of Filter = Q/Filtration Rate

Number of Filter Unit = $[3600 \,.\, Q/4.63]^{1/2}$

Area of One Filter Unit = Total Area of Filter/Number of Filter Unit

Width of Filter Bed = $[\text{Area of One Filter Unit}/R_{lw}]^{1/2}$

Length of Filter Bed = R_{lw}. Width of Filter Bed

$$\text{Depth of Sand Bed} = \left[\frac{1.239.10^8.\ \text{Filtration Rate}\ \{(D_{10}+D_{60})/2\}^3.h}{B_i\{60/(T_F+10)\}}\right]$$

where

$T_F = 1.80\ T + 32$

$B_i = 1.10^{-3}$ if Level of Water Pretreatment = Average

$B_i = 2.10^{-3}$ if Level of Water Pretreatment = High

$B_i = 6.10^{-3}$ if Level of Water Pretreatment = Excellent

Total Area of Perforations = R_{pf} . Area of One Filter Unit

where

R_{pf} = Ratio of Total Area of Perforations to Area of One Filter Unit = 0.003

UNITS

Q, $m^3\ s^{-1}$; Total Area of Filter, m^2; Filtration Rate $m\ s^{-1}$; Area of One Filter Unit, m^2; Width of Filter Bed, m; Length of Filter Bed, m; Depth of Sand Bed, m; D_{10}, m; D_{60}, m; h, m; Total Area of Perforations, m^2.

Equation Block 045

EQUATIONS

Diameter of Main Pipe = [4 . Area of Main Pipe/π]$^{1/2}$

where

Area of Main Pipe = R_{ml} . Total Area of Lateral

R_{ml} = Ratio of Area of Main Pipe to Total Area of Lateral = 1.5

Number of Laterals = (4 . Total Area of Laterals)/[π(Diameter of Lateral)^2]

Width of Filter Bed = Surface Area of One Filter Bed/R_{lw}

Length of Filter Bed = R_{lw} . Width of Filter Bed

Number of Laterals = (4 . Total Area of Laterals)/[π(Diameter of Lateral)^2]

Spacing of Lateral = Length of Filter Unit/ Number of Laterals

Length of Lateral = 0.5 (Width of Filter Unit - Diameter of Main Pipe)

UNITS

Diameter of Main Pipe, m; Area of Main Pipe, m^2; Total Area of Lateral, m^2; Diameter of Lateral, m; Width of Filter Bed, m; Surface Area of One Filter Bed, m^2; Length of Filter Bed, m; Width of Filter Bed, m; Spacing of Lateral, m; Length of Filter Unit, m; Length of Lateral, m; Width of Filter Unit, m; Diameter of Main Pipe, m.

Equation Block 046

EQUATIONS

Spacing of Orifices = Spacing of Lateral

Number of Orifices per Lateral = Length of Lateral/Spacing of Orifices

Diameter of Orifices = [4 . Area of Orifices/π]$^{1/2}$

where

Area of Orifice = Total Area of Perforations/Number of Orifices per Lateral

Equation Block 047 continued on page 140

Equation Block 047 continued from page 139

Total Number of Orifices = Number of Orifices per Lateral . Number of Lateral

Total Area of Orifices = π(Diameter of Orifices)^2 . Number of Orifices/4

First Counter = [1 - (Total Area of Perforations/Total Area of Orifices)]

UNITS

Diameter of Lateral, m; Spacing of Lateral, m; Spacing of Orifices, m ; Diameter of Orifices, m; Diameter of Main Pipes, m; Area of Orifice, m^2; Length of Lateral, m; Total Area of Orifices, m^2; Total Area of Laterals, m^2; Total Area of Perforations, m^2.

Equation Block 047

EQUATIONS

$$V_f = 1.30163(D_{60}/1000)^{1.82}.\{\rho_w-(\rho_{sand}-\rho_w)\}^{0.94}/\mu_T^{0.88}$$

where

$$\mu_T = 0.0016578e^{-0.02145T}$$

ρ_w = Mass Density of Water = 1000 kg m^{-3}

UNITS

V_f, m s^{-1}; ρ_{sand}, kg m^{-3}; ρ_w, kg m^{-3}; μ_T, kg s m^{-2}.

Equation Block 048

EQUATIONS

$$\text{Depth of Wash Water Trough} = \left[\frac{\text{Discharge of Wash Water}}{1.71\ \text{Width of Wash Water Trough}}\right]^{2/3}$$

$$\text{Modified Width of Wash Water Trough} = \left[\frac{\text{Discharge of Wash Water}}{1.71\ \text{Depth of Wash Water Trough}}\right]^{3/2}$$

Second Counter = ABS[(Width of Wash Water Trough/Modified Width of Wash Water Trough) - 1]

UNITS

Depth of Wash water Trough, m; Modified Width of Wash Water Trough, m; Width of Wash Water Trough, m.

Equation Block 051

EQUATIONS

Depth of Wash water Trough = Depth of Wash water Trough + Free board

Length of Wash Water Tank = $\{\text{Volume of Wash WaterTank}/(R_{flw} \cdot R^2_{wlw})\}^{1/}$

where

Volume of Wash Water Tank = 3 . Volume of Wash Water

Width of Wash Water Tank = Length of Wash Water Tank/R_{wlw}

Height of Wash Water Tank = Width of Wash Water Tank/R_{flw}

Total Height of Filter = Diameter of Main Pipe + Depth of Gravel Bed + Depth of Sand Bed + Free board + Water Depth Over Filter Bed.

UNITS

Depth of Wash water Trough, m; Modified Width of Wash Water Trough, m; Width of Wash Water Trough, m; Free board, m; Length of Wash Water Tank, m; Volume of Wash Water Tank, m^3;

Equation Block 052 continued on page 143

Equation Block 052 continued from page 142

Volume of Wash Water, m^3; Width of Wash Water Tank, m; Height of Wash Water Tank, m; Total Height of Filter, m; Diameter of Main Pipe, m; Depth of Gravel Bed, m; Depth of Sand Bed, m; Water Depth Over Filter Bed, m.

Equation Block 052

EQUATIONS

$$-4.948125\ n\ Q_{mgd}^{-0.3175}\ K^{0.6825} C_{opt}^{-(0.6825\ n+1)} + 0.5954\ Q_{mgd}^{-0.5654}\ C_{opt}^{-0.5654} + 0.16 = 0$$

where

$Q_{mgd} = 19.008 \ . \ Q$

n = Constant = 0.87

K = Constant = 26

C_{opt} = Optimum Chlorine Dose

UNITS

Q_{mgd}, million gallon/day; Q, $m^3\ s^{-1}$; C_{opt}, Pound/Million Gallons.

Equation Block 053

EQUATIONS

Additional Chlorine Dose = 2.1 Hydrogen Sulphide Concentration + 0.63 Iron Concentration + 1.3 Manganese Concentration + 10 Ammonia Concentration

UNITS

Additional Chlorine Dose, $g\ l^{-1}$; Hydrogen Sulphide Concentration, $g\ l^{-1}$; Iron Concentration, $g\ l^{-1}$; Manganese Concentration, $g\ l^{-1}$; Ammonia Concentration, $g\ l^{-1}$.

Equation Block 054

EQUATIONS

Contact Time = $3600\ K/C^{n}_{opt}$

where

n = Constant = 0.87

K = Constant = 26

C_{opt} = Optimum Chlorine Dose

Total Chlorine Dose = $8.21.10^{-8}C_{opt}$ + Additional Chlorine Dose

Daily Disinfectant Requirement = 24.(3600) . Q . Dose of Disinfectant

where

Dose of Disinfectant = Total Chlorine Dose/x

x =	1.00 for Type of Disinfectant =	Chlorine
	0.36	Bleaching Powder
	0.72	Calcium Hypochlorite
	0.14	Sodium Hypochlorite
	2.63	Chlorine Dioxide
	1.38	Monochloroamine
	1.65	Dichloroamine
	1.77	Trichloroamine

UNITS

Q, $m^3\ s^{-1}$; C_{opt}, Pound(Million Gallons)$^{-1}$; Additional Chlorine Dose, $g\ l^{-1}$; Total Chlorine Dose, $kg\ m^{-3}$; Dose of Disinfectant, $kg\ m^{-3}$; Daily Disinfectant Requirement, kg.

Equation Block 055

EQUATIONS

Volume of Tank = Q . Contact Time

Length of Tank = $[\text{Volume of Tank}/(R^{2}_{lw}\ R_{wh})]^{1/3}$

Width of Tank = Length of Tank/R_{lw}

Height of Tank = Width of Tank/R_{wh}

Width of Channel = Height of Tank/R_{hw}

Length of Channel = Width of Tank

Number of Channels = Length of Tank/Width of Channel

Equation Block 056 continued on page 145

Equation Block 056 continued from page 144

Length of Baffle = Width of Tank - Width of Channel

Height of Baffle = Height of Tank

UNITS

Volume of Tank, m^3; Q, $m^3\ s^{-1}$; Contact Time, s; Length of Tank, m; Width of Tank, m; Height of Tank, m; Width of Channel, m; Length of Channel, m; Length of Baffle, m; Height of Baffle, m.

Equation Block 056

EQUATIONS

$$-4.948125\ n\ Q_{mgd}^{-0.3175}\ K^{0.6825}\ C_{opt}^{-(0.6825\ \ n+1)} + 0.5954 Q_{mgd}^{-0.5654}\ C_{opt}^{-0.5654} + 0.16 = 0$$

where

Q_{mgd} = 19.008 . Q

n = Constant = 1.74

K = Constant = 128

C_{opt} = Optimum Chlorine Dose

UNITS

Q, million gallon day^{-1}; Q, $m^3\ s^{-1}$; C_{opt}, Pound (Million Gallons)$^{-1}$

Equation Block 057

EQUATIONS

Contact Time = 3600 K/C_{opt}^n

where

n = Constant = 1.74

K = Constant = 128

C_{opt} = Optimum Chlorine Dose

Equation Block 058 continued on page 146

Equation Block 058 continued from page 145

Total Chlorine Dose = $8.21.10^{-8} C_{opt}$

Daily Disinfectant Requirement = 24.(3600) . Q . Dose of Disinfectant

where

Dose of Disinfectant = Total Chlorine Dose/x

x =	for Type of Disinfectant =
1.00	Chlorine
0.36	Bleaching Powder
0.72	Calcium Hypochlorite
0.14	Sodium Hypochlorite
2.63	Chlorine Dioxide
1.38	Monochloramine
1.65	Dichloroamine
1.77	Trichloroamine

UNITS

Q, $m^3 s^{-1}$; C_{opt}, Pound (Million Gallons)$^{-1}$; Additional Chlorine Dose, $g\ l^{-1}$; Total Chlorine Dose, $kg\ m^{-3}$; Dose of Disinfectant, $kg\ m^{-3}$; Daily Disinfectant Requirement, kg.

Equation Block 058

EQUATIONS

Volume of Tank = Q . Contact Time

Length of Tank = [Volume of Tank/$(R_{lw}^2\ R_{wh})]^{1/3}$

Width of Tank = Length of Tank/R_{lw}

Height of Tank = Width of Tank/R_{wh}

Width of Channel = Height of Tank/R_{hw}

Length of Channel = Width of Tank

Number of Channels = Length of Tank/Width of Channel

Length of Baffle = Width of Tank - Width of Channel

Height of Baffle = Height of Tank

UNITS

Volume of Tank, m^3; Q, $m^3 s^{-1}$; Contact Time, s; Length of Tank, m; Width of Tank, m; Height of Tank, m; Width of Channel, m; Length of Channel, m; Length of Baffle, m; Height of Baffle, m.

Equation Block 059